



**DEVELOPMENT SERVICING SCENARIO -
WESTPHAL**

Future Serviced Communities

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Development Servicing Scenario - Westphal

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Development Servicing Scenario - Westphal

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1 Introduction

The Halifax Regional Municipality (HRM), through their Regional Municipal Planning Strategy (Regional Plan), have identified four Future Serviced Communities which require a comprehensive neighbourhood planning process that includes a review of existing servicing infrastructure capacity and constraints. The four study areas are as follows.

- Sandy Lake
- Highway 102 Corridor
- Morris Lake
- Westphal (identified as Akoma Lands in the RFP)

This report summarizes the following with respect to the Westphal development:

- Design criteria and regulatory considerations,
- Development scenarios,
- Potable water serviceability,
- Existing wastewater collection system, and
- Development grading.

Conceptual servicing plan measures to meet the established design criteria, and upgrades required to regional infrastructure for water and wastewater servicing, are also discussed.

2 Background and Design Criteria

2.1 Regulatory Considerations

2.1.1 HALIFAX WATER (HW)

HW's *Design Specifications and Supplementary Standard Specifications for Water, Wastewater & Stormwater Systems*, 2023 Edition (DS & SSS) outline the following objectives relating to the design of new servicing systems. This report is to be read in conjunction with the Westphal Water Servicing Plan report (**Appendix A**).

2.1.1.1 Water Distribution System Design

The watermain system shall:

- Be designed to accommodate the greater of Maximum Day Demand plus fire flow demand, or Peak Hour Demand.
- Average Day Demand corresponds to 375 L/person/day.
- Fire flow demand to be in accordance with latest requirements per Fire Underwriter's Survey (FUS) *Water Supply for Public Fire Protection* (2020), and estimated per DS & SSS Table 3.3:

Land Use	Fire Flow (litres/minute)	Duration (hours)	Number of Fire Hydrants
Single unit dwellings	3300	1.5	1
Two family dwellings	3300	1.5	1
Townhouse	4542	1.75	1
Multi-unit high rise	13620	3	3
Commercial	13620	3	3
Industrial	13620	3	3
Institutional	13620	3	3

- Peaking factors are as per DS & SSS Table 3.1:

Land Use	Minimum Hour	Maximum Day	Peak Hour
Low Density Residential	0.70	1.65	2.50

High Density Residential	0.84	1.30	2.50
Industrial	0.84	1.10	0.90
Commercial	0.84	1.10	1.20
Institutional	0.84	1.10	0.90

- Minimum size for local distribution mains is 200mm, minimum size for Feeder Main is 300mm.

Additional requirements for watermain are noted in the accompanying Stantec report *Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan (Appendix A)*.

2.1.1.2 Wastewater System – Design Requirements

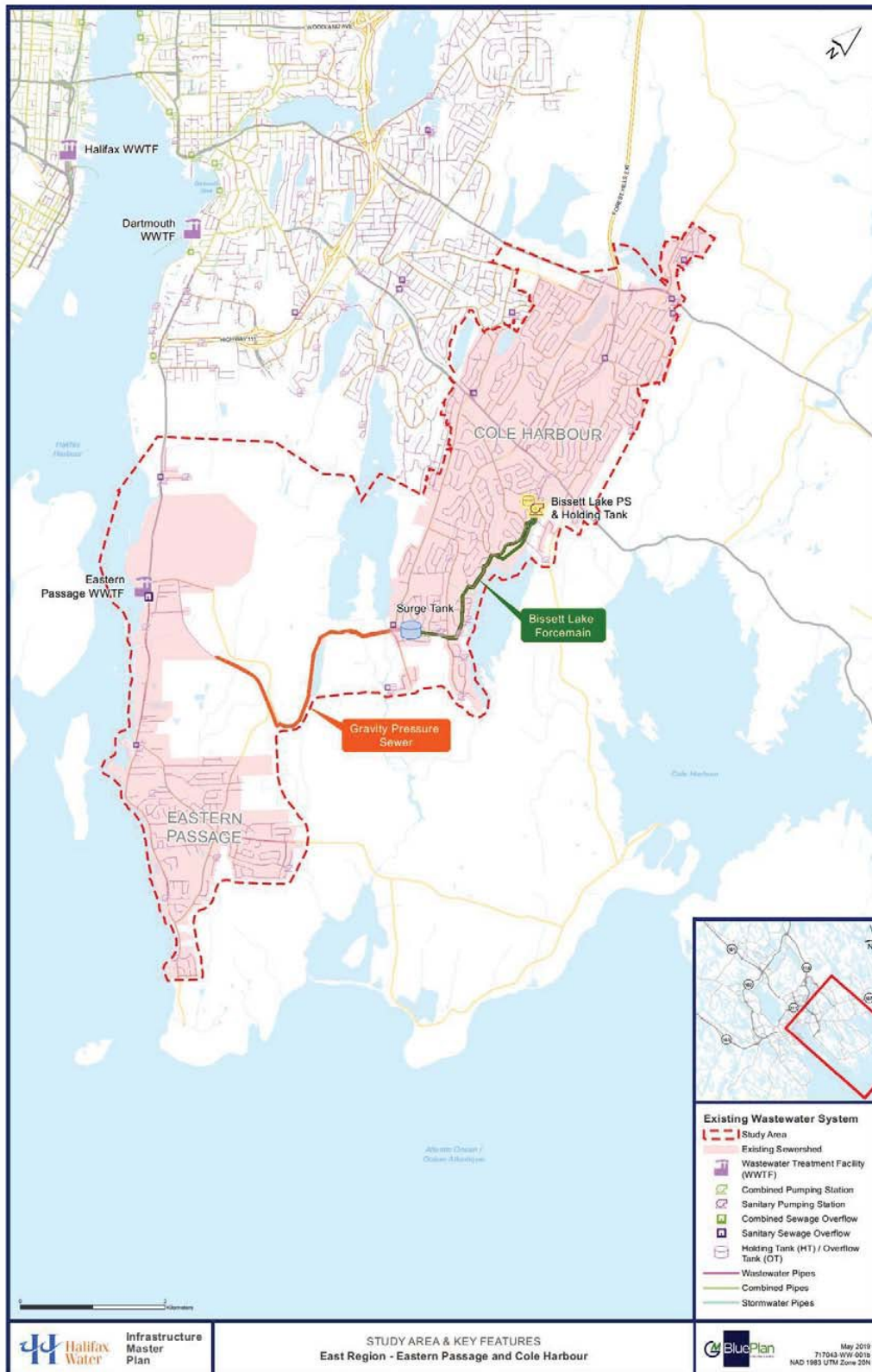
- Average Dry Weather flow corresponds to 300 L/person/day (noted as 375 L/person/day in proposed design sheets to account for 25% safety factor in peak design flows per HW design specifications).
- Peak Dry Weather flow to be determined using peaking factor per the Harmon Formula (minimum of 2.0).
- Infiltration / inflow allowance of 24 m³/ha/day to be used.
- Pipe minimum and maximum velocities of 0.75m/s and 4.5 m/s respectively, and up to 6.0 m/s with additional energy dissipation and ventilation measures.
- Mannings Roughness coefficients applied per DS & SSS Table 4.1:

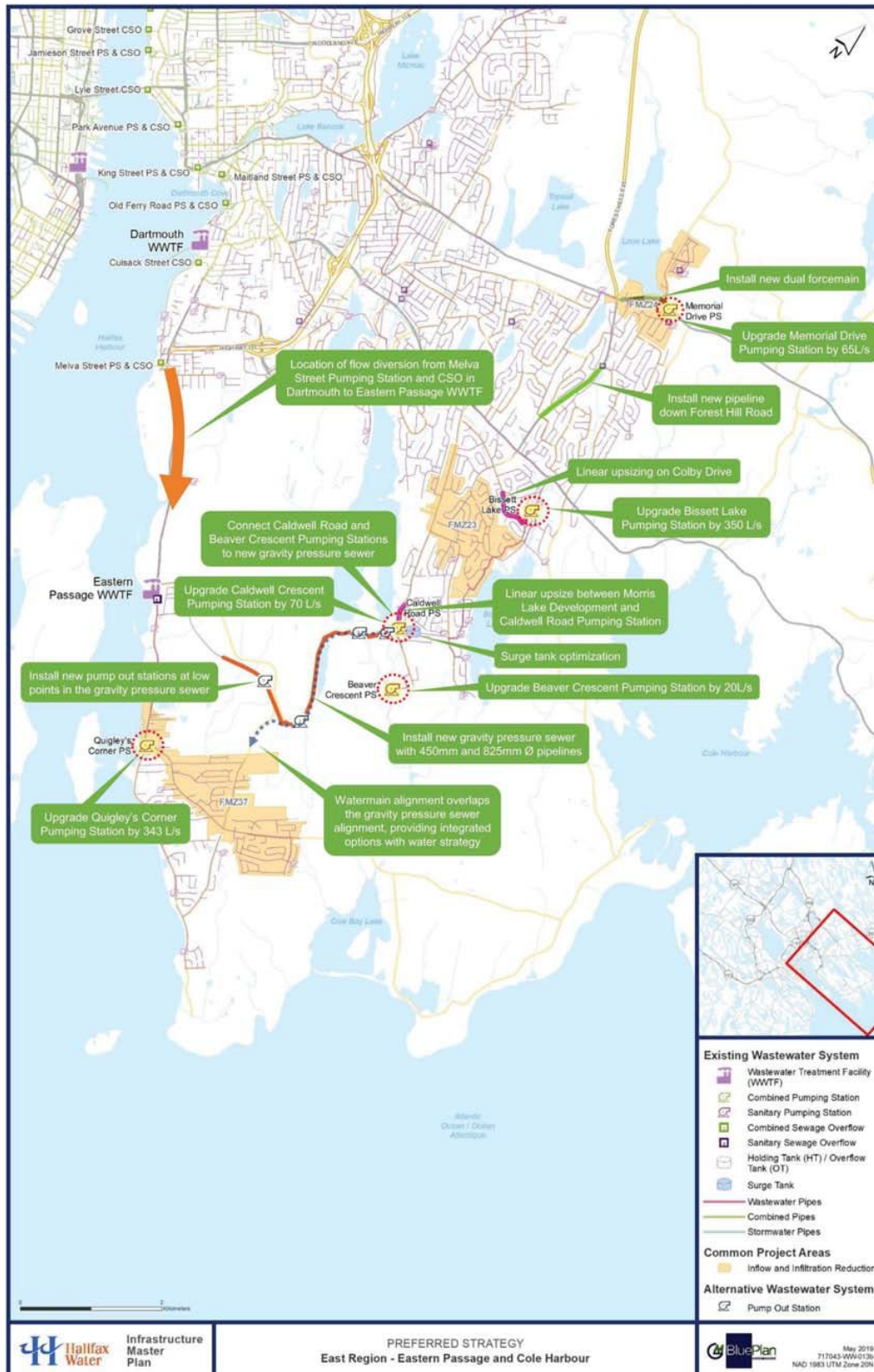
PIPE MATERIAL	MANNING ROUGHNESS
Concrete	0.013
PVC	0.010
Polypropylene	0.012
HDPE (Smooth Interior Wall)	0.012

- Minimum wastewater main size of 250mm, and minimum grade of 0.6%.
- Minimum cover is 1.6m, and maximum cover is 5.0m with deeper trunk sewers on exception basis and where a local sanitary sewer for service connections is provided.
- Pump stations classified as Small (firm capacity to 75 L/s), Medium (firm capacity between 75 L/s and 220 L/s), and Large (firm capacity > 220 L/s).

2.2 Infrastructure Master Plan – East Region Wastewater Infrastructure Plan Final Report Volume 5

As noted in the Wastewater Infrastructure Plan, growth in this region has been considered to be largely tributary to the gravity pressure trunk sewer to the Eastern Passage WWTF via the Bissett Lake PS. Only a modest flow increase has been assigned to the nearby Memorial Drive PS, and largely to control local flooding and I/I concerns.





2.3 Infrastructure Master Plan – Water Infrastructure Servicing Plan Final Report Volume 2

The IMP provides a schematic for the Lake Major distribution system providing service to the Westphal development area. Additionally, the IMP identifies that a servicing study was completed for the Eastern Passage area that recommended a second connection from Cole Harbour to Eastern Passage, along Caldwell Road, to support the existing 400mm diameter single feed to the area along Pleasant Street / Main Road. This would improve fire flow protection, operation of Woodside Low and Eastern Passage Low pressure zones, provide security of supply to the area, and overall system looping.



2.4 Other Regional Considerations

2.4.1 WATER MODELLING

It was noted that water modeling was carried out using an isolated steady-state model for each of the four proposed development sites. Stantec's water servicing report (provided in Appendix A) recommended that the modeling for the proposed developments should be based on using a full system model so that the effect of the proposed developments on the level of service on the remaining water system can be assessed. Similarly, the report noted that modeling of the development sites only would not identify potential restrictions in the system that may impact the development sites. It was noted that this approach was outside of the scope of the services for the study as the system fall under the Halifax Water Regional Authority. **Considering the scale of the proposed developments and potential impacts on existing water systems and off-site infrastructure upgrades, the recommended full system modeling should be carried out as part of the upcoming update of the Integrated Resource Plan (IRP).**

2.4.2 REGIONAL WATER

The 2019 IMP did not consider the Westphal Development area as a planned growth area. Therefore, the need for regional water system improvements to service the Westphal Development have not been previously identified. However, The IMP did note that the Lake Major system supply does not have sufficient capacity to accommodate expected growth to the year 2046. It was estimated that by 2031 75% of the supply capacity will be used and by 2041 demands will reach 90% of the supply capacity triggering the need for a new supply source. These proposed timelines did not include servicing the Westphal development (see **Figure 2-1** taken from the 2019 IMP).

The IMP noted that it not possible to increase the withdrawal permit from Lake Major, and that there is little, or no, opportunity to cost effectively develop a new source near the Lake Major network. However, there is a possibility to alleviate some of the demand on Lake Major by a system connection from the Pockwock network.

It is recommended that the current IMP examine the effects of the Westphal development on the existing regional system to identify required infrastructure improvements and/or servicing limitations.

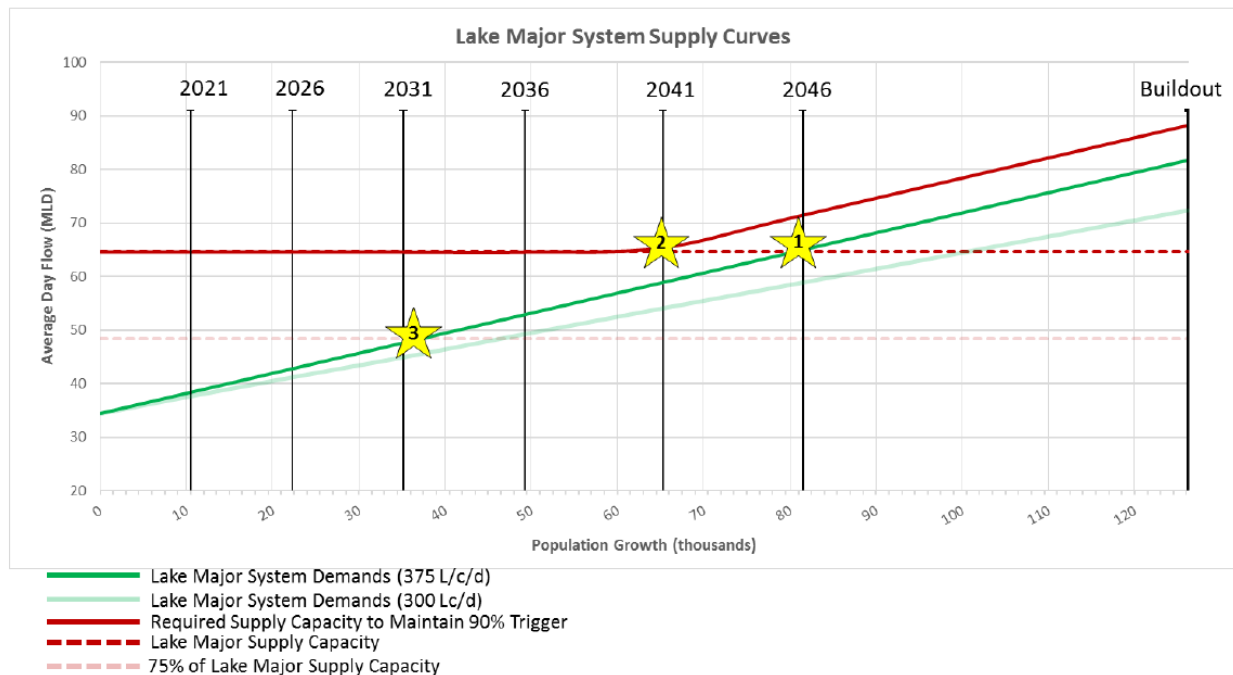


Figure 2-1: Supply Analysis for Lake Major System (taken from 2019 IMP)

2.4.2.1 Potential Regional Water Infrastructure Improvements

Given the relatively small diameter watermain in Main Street (300 mm), Ritcey Crescent (300 mm) and Ross Road (250 mm) it is suspected that the full regional water model will identify the need for improvements to existing infrastructure to service the Westphal development. This should be confirmed through the development of the new IMP.

Two potential infrastructure improvements have been identified, which could potentially improve the serviceability of the Westphal development and should be further explored in the regional hydraulic model. These include the following:

- Option 1: A new reservoir at the high elevation point adjacent to Maclaughlin Rd. The tank would be fed from the existing 1050 mm transmission main in Maclaughlin Rd (from the Lake Major Water Treatment Facility). A dedicated transmission main connected to the new tank would then be needed in Maclaughlin Rd south to Highway 7, then east along Highway 7 to the Westphal site. The ground elevation of the tank site is approx. 80 – 85 m. Given the highest elevation in the Westphal development is approx. 60 m, to establish 50 psi at the 60 m the low operating level of the tank would need to be around 95-96 m (ignoring friction loss).

Given the large difference in MDD between the low and high population density scenarios (800 Lpm vs 12,251 Lpm, respectively) an approx. tank volume has not been estimated. **Figure 2-2** illustrates option 1. Transmission main diameter of 600 mm has been assumed but should be further evaluated.

- Option 2 involves installing new 600 mm diameter watermain in Main Street (Hwy 7) and Cole Harbour Road from the existing 600 mm watermain on Wildwood Blvd/Forest Hills Pky to the Westphal development, as illustrated in **Figure 2-3** below.

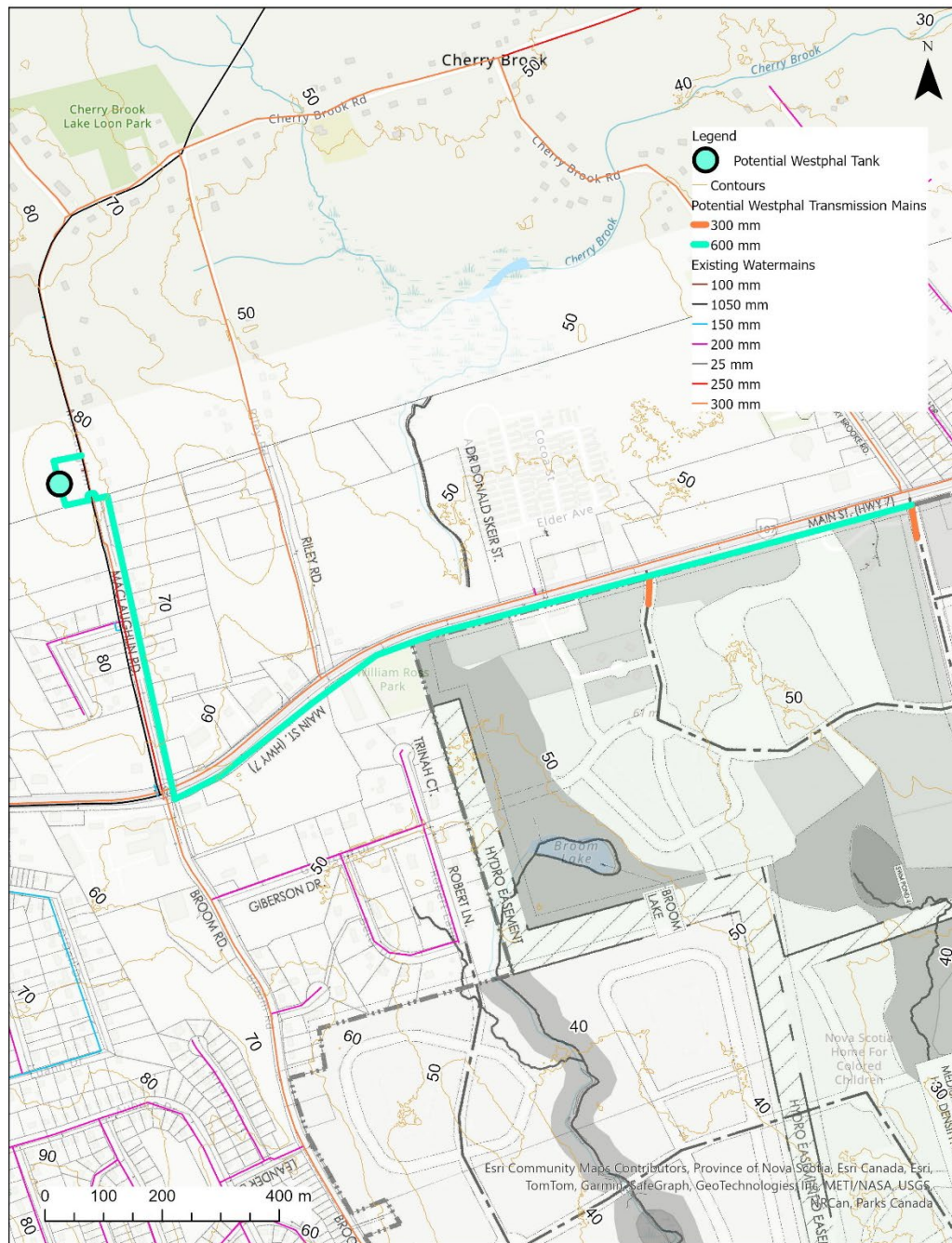


Figure 2-2: Option 1 - New Tank and Transmission Main

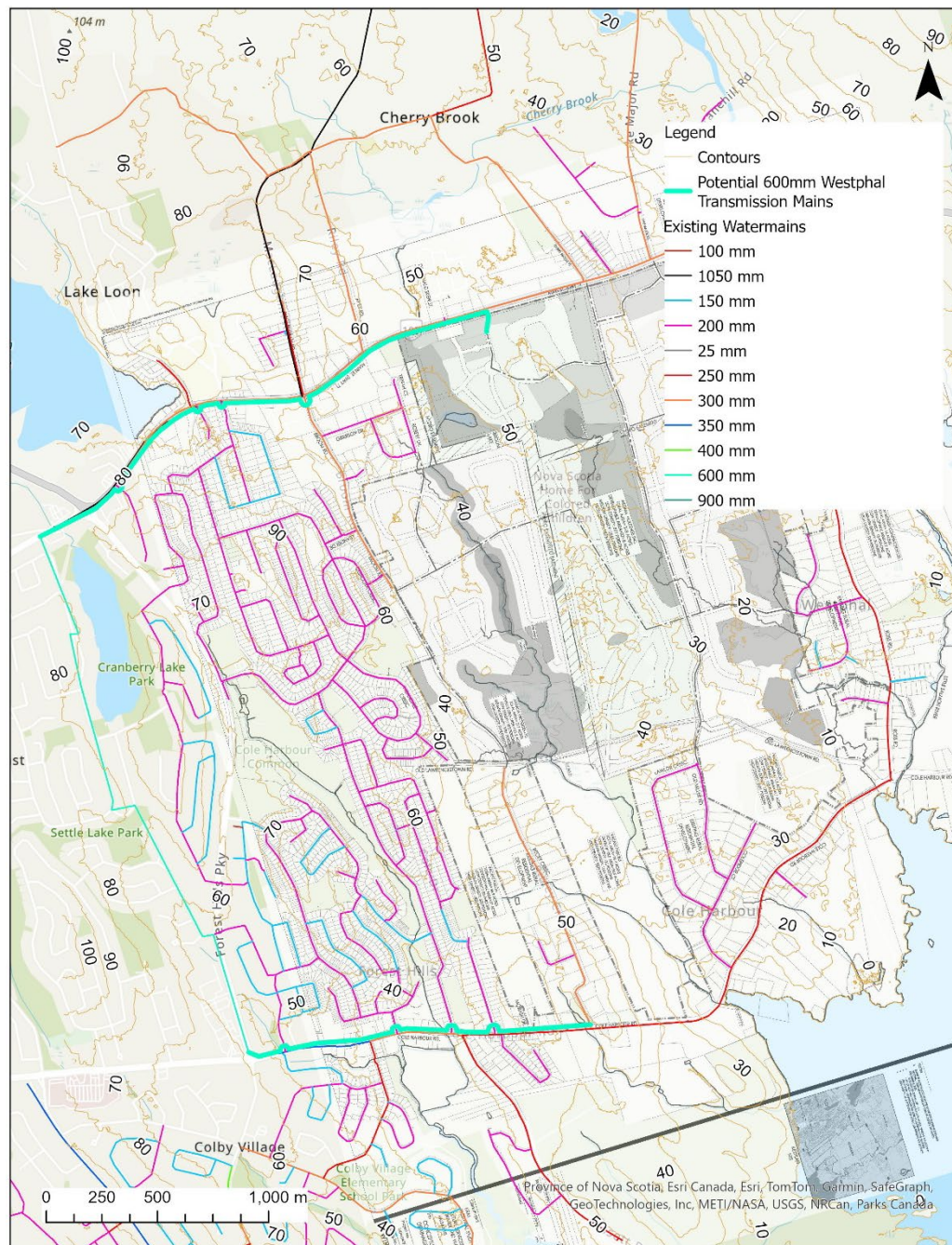


Figure 2-3: Option 2 - Upsizing Main Street and Cole Harbour Road Watermains

2.4.3 WASTEWATER

As detailed further in Section 5, the Westphal lands are expected to have impacts on the conveyance upgrades identified in the 2020 WIP in particular concerning the pressure-gravity system and the Bisset Lake PS and storage facility. This system collects flow from a large area and a number of pump stations before discharging downstream towards the EP WWTF. Additional considerations for the Westphal lands on the conveyance system include the impacts on the linear infrastructure between Bisset Lake PS and Caldwell Road PS, as well as the Memorial Drive PS. These linear upgrades were identified as needed between 2031-2046 in the 2020 WIP. It may be feasible to incorporate the Westphal lands contribution in these upgrades, however the magnitude of the flows may trigger other options as being more favorable.

As discussed further in Section 5.1, this consideration merits the use of the City's updated hydraulic model assessed in context of regional servicing needs within the framework of the IMP. This includes alternatives evaluations to determine a preferred regional servicing and infrastructure upgrades strategy that best accommodates the broader needs and goals of the HRM and HW. This note is also applicable to the Morris Lake FSC lands interest and the cumulative impact of both these growth areas should be considered.

It is further recommended that HW and HRM revisit the technical and financial evaluations of the servicing strategy for the EP WWTF. A cost-benefit analysis would enhance the confidence that the implemented servicing strategies to come are best aligned with HW and HRM priorities, while maintaining (or enhancing) service to existing residents and proactively planning those infrastructure upgrades required to maintain this same level of service to future growth areas. Such an analysis would align well within the context and scope of an IMP update.

2.4.4 CAPITAL COST CONTRIBUTIONS (CCC)

Critical infrastructure that provides a regional benefit would form part of a Capital Cost Contribution Policy (CCC) for the area. Infrastructure that may be eligible for cost-sharing include reservoirs, control chambers, booster stations and watermains that are 400mm and greater in diameter. The cost of the applicable portions of reservoir storage, PRVs and main oversizing would form components of a water CCC for the development area.

As noted previously, the study did not analyze the development as part of a full system hydraulic model. As a result, the scope of any required regional infrastructure to support this development is not yet known and any estimates for CCCs based on this study may be incomplete. **It is recommended that the Capital Cost Contribution be updated following completion of the Master Servicing Plan for the Westphal Area, and the Regional Infrastructure Plan update.**

3 Development Scenarios

Stantec has attempted to prepare a conceptual development plan considering local and major connecting roadways, residential development areas, commercial development areas, and greenspace and parks. This concept was heavily influenced by previously prepared development plans by major landowners for the area – Kiel Development, Akoma Holdings, Annada Properties, and Jim Morash Construction.

Developer-considered unit density for residential development areas has been superseded for the overall concept in order to develop three density scenarios (identified as Low, Medium, and High) for each development area as described in the *Development Scenario – Westphal Study Area (Stantec, 2024)* report. Recognizing that each development area has unique features and environmental constraints, the following methodology was applied in order to develop residential unit density for each development scenario:

1. Determining the properties comprising each area defined in the HRM Request for Proposals from current Nova Scotia Property Online records.
2. Summing the area of properties recorded in Nova Scotia Property Online records.
3. Subtracting already developed or assigned lands (i.e., lands that have buildings or a designated use such as parkland or road rights-of-way) to determine land available for development.
4. Compiling all development proposed for each study area based on plans or other input from landowners indicating an interest in development to determine the “developer-requested scenario” for each study area.
5. Calculating potential development for remaining lands based on patterns determined from **Step 4** (i.e., assuming remainder lands would be developed with similar density and unit mix as proposed by developers).
6. Determining areas that are wetland and/or 30-metre watercourse buffers (i.e., environmentally constrained) within each area and converting to a percentage for each study area.
7. Excluding the percentage of environmentally constrained land (i.e., wetlands and watercourse buffers) from lands available for development (i.e., subtracting the percentage of land that is environmentally constrained determined for each study area in **Step 6** from land available for development calculated through **Step 3**).
8. Applying an overall population density or similar parameter to create two alternative development scenarios for each study area.
9. Calculating a distribution of residential units by type for each study area based on the distribution of dwelling unit types (i.e., singles, townhouses, apartments) in developer-requested proposals for the specific study area.

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10. Calculating commercial space (i.e., gross leasable area or GLA) using the square foot area per person of commercial space provided by developers in submitted plans applied to the total estimated population for each study area and rounded up to the nearest 5,000 square.

Estimates of environmental constraints are based on desktop investigations and measurement in GIS and estimates. The more important consideration is that developer intentions are accurately reflected in developer-requested scenarios, that those intentions are reasonably reflected in alternative scenarios, and both estimation and analysis are consistent across the study areas and their component developments.

Westphal – High (Developer-requested)

Developer	Land Area (ac.)		Dwelling Units				Estimated Population		Commercial GLA (sq. ft.)	
	Total	Developable	Unit Type	Unit Numbers	Density	Share by Type	Residents	Density	Per Resident	Total Area
Kiel Development	262	182.8	Singles	153		3.0%	398			
			Stacked Towns	760		15.1%	1,976			
			Multi-unit	4,122		81.9%	7,420			
			All types	5,035	27.5	100.0%	9,793	53.6	15.6	155,000
Akoma Holdings	318	221.8	Singles	202		4.3%	525			
			Stacked Towns	740		15.6%	1,924			
			Multi-Unit	3,791		80.1%	6,824			
			All types	4,733	21.3	100.0%	9,273	41.8	9.8	95,000
Annada Properties	217	151.2	Singles	56		1.2%	146			
			Stacked Towns	1,390		31.0%	3,614			
			Multi-unit	3,040		67.8%	5,472			
			All types	4,486	29.7	100.0%	9,232	61.0	0.0	0
Jim Morash Construction	14	9.9	Singles	5	0.5	100.0%	13	1.3		
Remainder	216	150.6	Singles	111		2.9%	288			
			Stacked Towns	769		20.3%	2,000			
			Multi-unit	2,901		76.7%	5,222			
			All types	3,781	25.1	100.0%	7,523	50.0	8.6	65,000
STUDY AREA	1,028	716.4	All development	18,040	25.2		35,834	50.0	8.6	310,000

Westphal - Low-density

Developer	Land Area (ac.)		Dwelling Units				Estimated Population		Commercial GLA (sq. ft.)	
	Total	Developable	Unit Type	Unit Numbers	Density	Share by Type	Residents	Density	Per Resident	Total Area
Kiel Development	262	182.8	Singles	183	1.0	100.0%	475	2.6	8.6	5,000
Akoma Holdings	318	221.8	Singles	222	1.0	100.0%	577	2.6	8.6	5,000
Annada Properties	217	151.2	Singles	151	1.0	100.0%	393	2.6	8.6	5,000

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Jim Morash Construction	14	9.9	Singles	10	1.0	100.0%	26	2.6		
Remainder	216	150.6	Singles	151	1.0	100.0%	391	2.6	8.6	5,000
STUDY AREA	1,028	716.4	All development	716	1.0		1,863	2.6	8.6	20,000

Westphal - Mid-density

	Land Area (ac.)		Dwelling Units				Estimated Population		Commercial GLA (sq. ft.)	
Developer	Total	Developable	Unit Type	Unit Numbers	Density	Share by Type	Residents	Density	Per Resident	Total Area
Kiel Development	262	182.8	Singles	161		3.2%	418			
			Townhouses	799		15.9%	2,078			
			Multi-unit	4,054		80.9%	7,297			
			All types	5,014	27.4	100.0%	4,571	25.0	8.6	40,000
Akoma Holdings	318	221.8	Singles	121		4.3%	314			
			Townhouses	442		15.6%	1,150			
			Multi-unit	2,267		80.1%	4,081			
			All types	2,830	12.8	100.0%	5,545	25.0	8.6	50,000
Annada Properties	217	151.2	Singles	23		1.2%	60			
			Townhouses	569		31.0%	1,480			
			Multi-unit	1,245		67.8%	2,242			
			All types	1,837	12.1	100.0%	3,781	25.0	8.6	35,000
Jim Morash Construction	14	9.9	Ground-based	96	9.6	100.0%	249	25.0		
Remainder	216	150.6	Singles	55		2.9%	142			
			Townhouses	385		20.3%	1,002			
			Multi-unit	1,456		76.8%	2,620			
			All types	1,896	12.6	100.0%	3,764	25.0	8.6	35,000
STUDY AREA	1,028	716.4	All development	11,673	16.3		17,909	25.0	8.6	155,000

Estimated populations have been distributed amongst the development concept area to facilitate local infrastructure sizing and to define capacity constraints for off-site works.

4 Potable Water Infrastructure

To assess the ability of servicing the Westphal development by existing pressure zones, and to identify infrastructure required to meet the level of service prescribed in HW's DS & SSS, a steady state water network model of the proposed development was built in Innovyze InfoWater Pro 3.5. The water model was used to assess both the high-density and low-density population scenarios presented in **Section 3**. The following sub-sections summarize the water servicing analysis completed for the Westphal development, while **Appendix A** contains the full *Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan – Final Report*.

4.1 Connectivity to Municipal Infrastructure

The proposed Westphal development is located adjacent to the Ross Road Low, Ritcey Low, and 24 East High pressure zones. These pressure zones are included in the Lake Major system and are serviced by the Lake Major Water Treatment Facility.

The hydraulic grade lines (HGL) of the adjacent pressure zones are summarized in the following table and illustrated in **Figure 4-1**.

Table 4-1: Adjacent Pressure Zones Hydraulic Grade Lines

Pressure Zone	HGL (m)	HGL (ft)
Ross Road Low	71-74	233-242
Ritcey Low	88-91	290-300
24 East High	116-119	380-390

Comparing the serviceable elevation ranges of the adjacent pressure zones to the development elevation ranges indicate that the re-delineation of the three pressure zones can accommodate the development from a pressure perspective. However, pressures within the Westphal development area serviced by the 24 East High zone are anticipated to be greater than the range specified in HW's DS & SSS. In these areas pressure reducing valves installed on the water service lines (in accordance with HW SSS) should be considered. Alternatively, a new pressure zone, south of Highway 7, may also be considered during the next design phase. It is assumed the new pressure zone would be controlled by a pressure reducing valve from the 24 East High pressure zone. The proposed pressure zone re-delineations are illustrated in **Figure 4-2**.

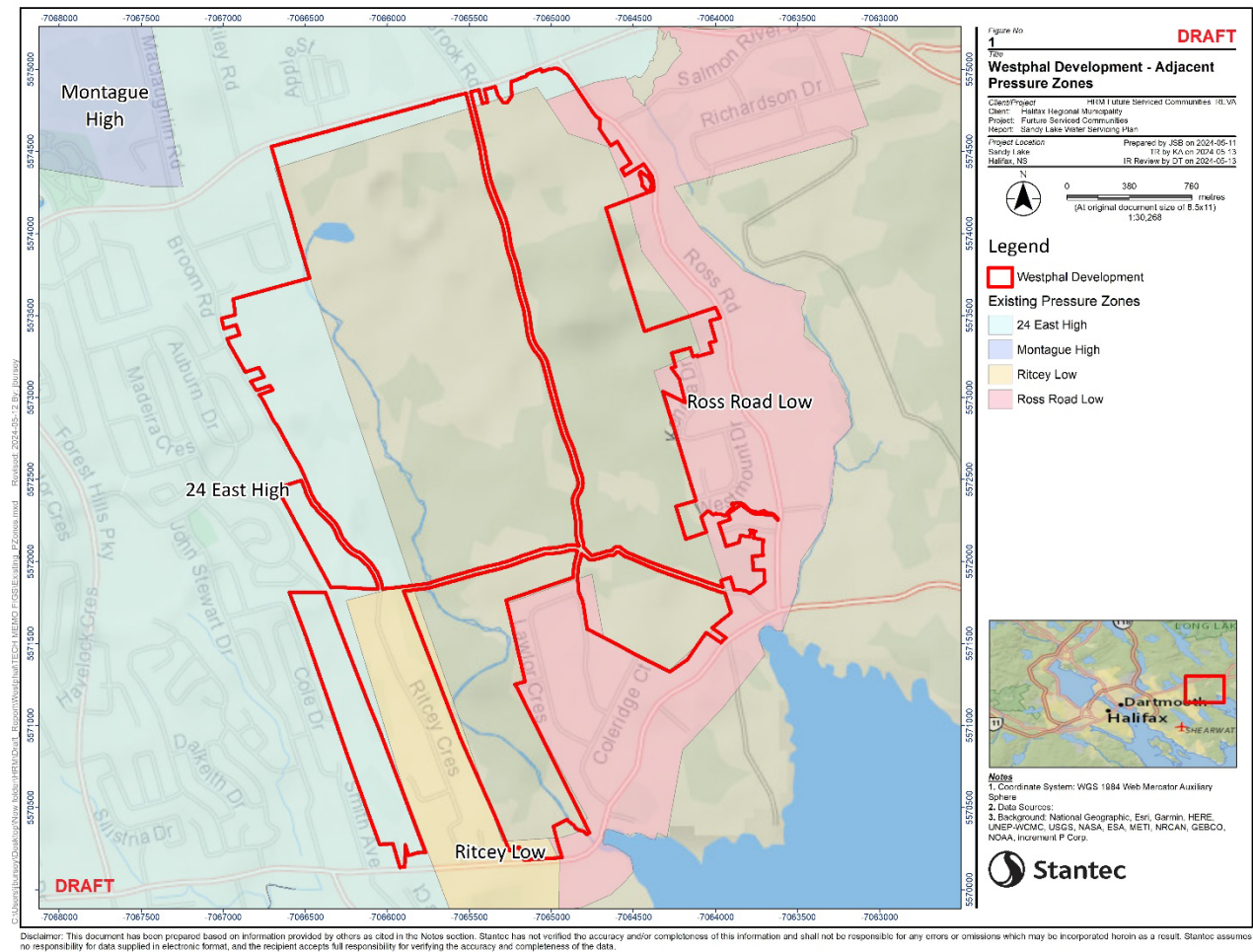


Figure 4-1: Existing Pressure Zones

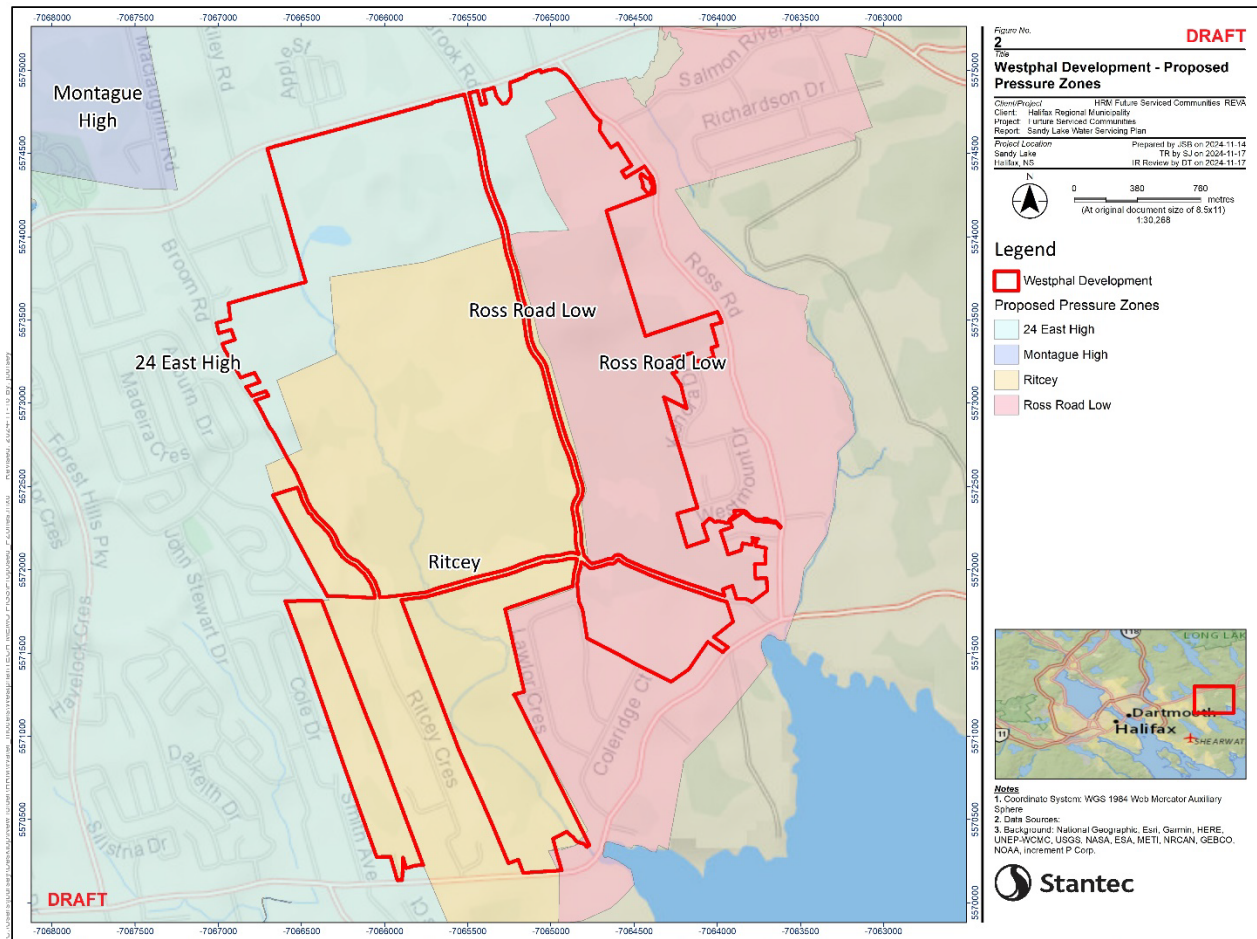


Figure 4-2: Proposed Pressure Zone Re-Delineation

4.2 Water Model

A steady state water network model of the proposed development was built in Innovyze InfoWater Pro 3.5 to assess distribution system requirements within the development to accommodate the MHD, MDD, PHD and MDD+ fire flow (FF) demands for the high-density and low-density scenarios. Reservoirs with fixed head equal to the pressure zones' HGL were used to simulate the connections to the existing Ross Road Low, Ritcey Low and 24 East High pressure zones. It is noted that modelling the existing system in this manner does not reflect the actual system, as it assumes the connecting points are always at a constant HGL regardless of demand scenario and that there is an unlimited supply of water from the zone. However, in the absence of a full system model it is a reasonable assumption.

Currently, the three pressure zone extension areas are modeled as being serviced by single feeds. However, it is anticipated that during detailed design/construction, the watermain within the new serviced area will be connected and isolation valves and/or pressure reducing valves (PRV) used to maintain the pressure boundaries. Such design allows for redundancy; in the event of a watermain break the pressure zone boundary valve(s) can be opened and act as a secondary feed until repairs to the watermain can be made. Isolation valves, used to separate the pressure zones, are mimicked in the model by “closing” pipes.

The resultant pressures in consideration of the PHD for the high-density scenario are presented in **Figure 4-3** and available fire flows under MDD and the high-density scenario are shown in **Figure 4-4**. Pressures under the PHD scenario range from approximately 48 psi to 108 psi. In general, the pressures in the 24 East High development exceed the range specified for MHD, MDD, and PHD. The available fire flow range is approximately 4,500 Lpm to 28,500 Lpm and meets or exceeds total MDD + FF demands.

Additional modeled scenarios are available for review within the *Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan* report presented in **Appendix A**.

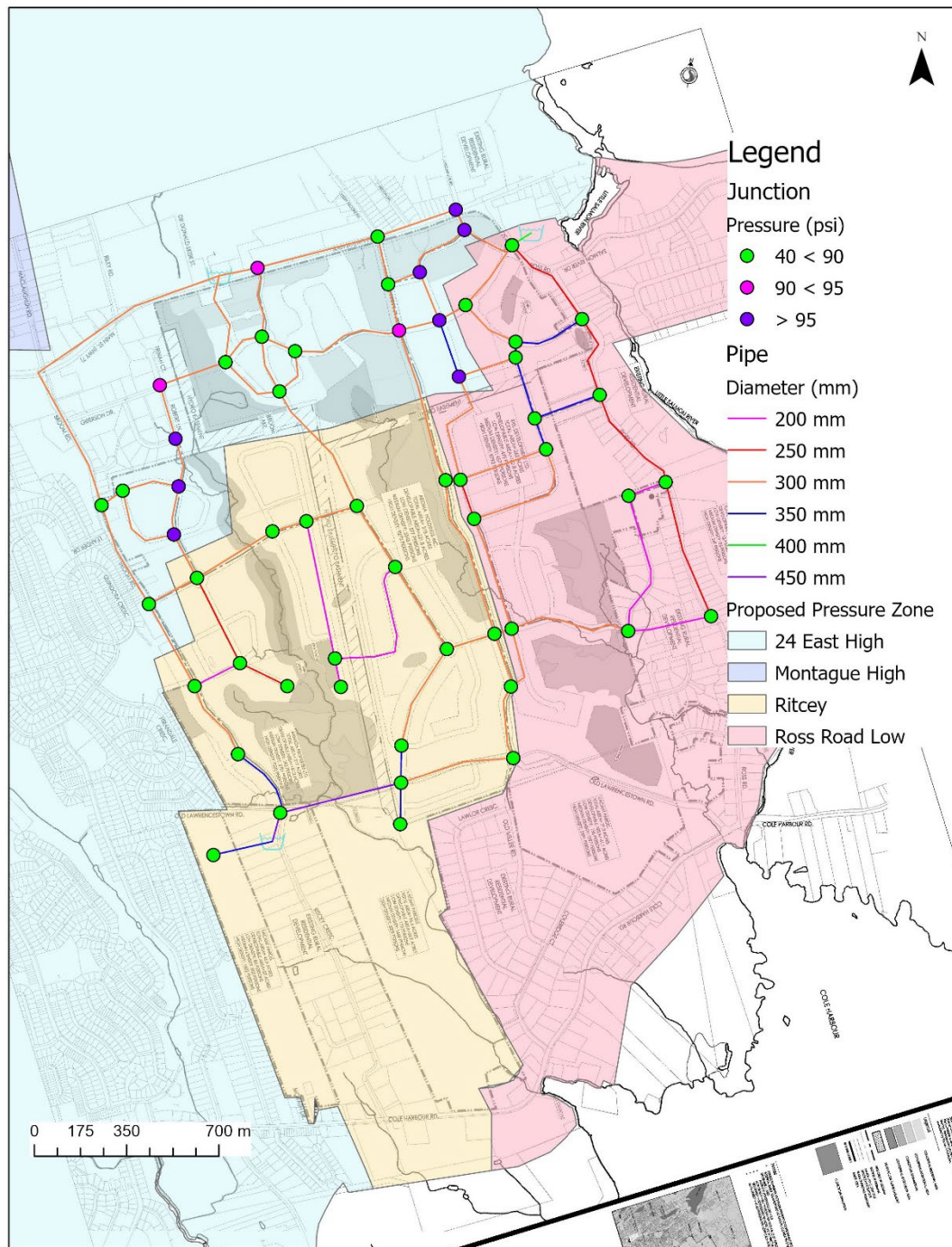


Figure 4-3: Pressure Distribution Under PHD (High-Density Scenario)

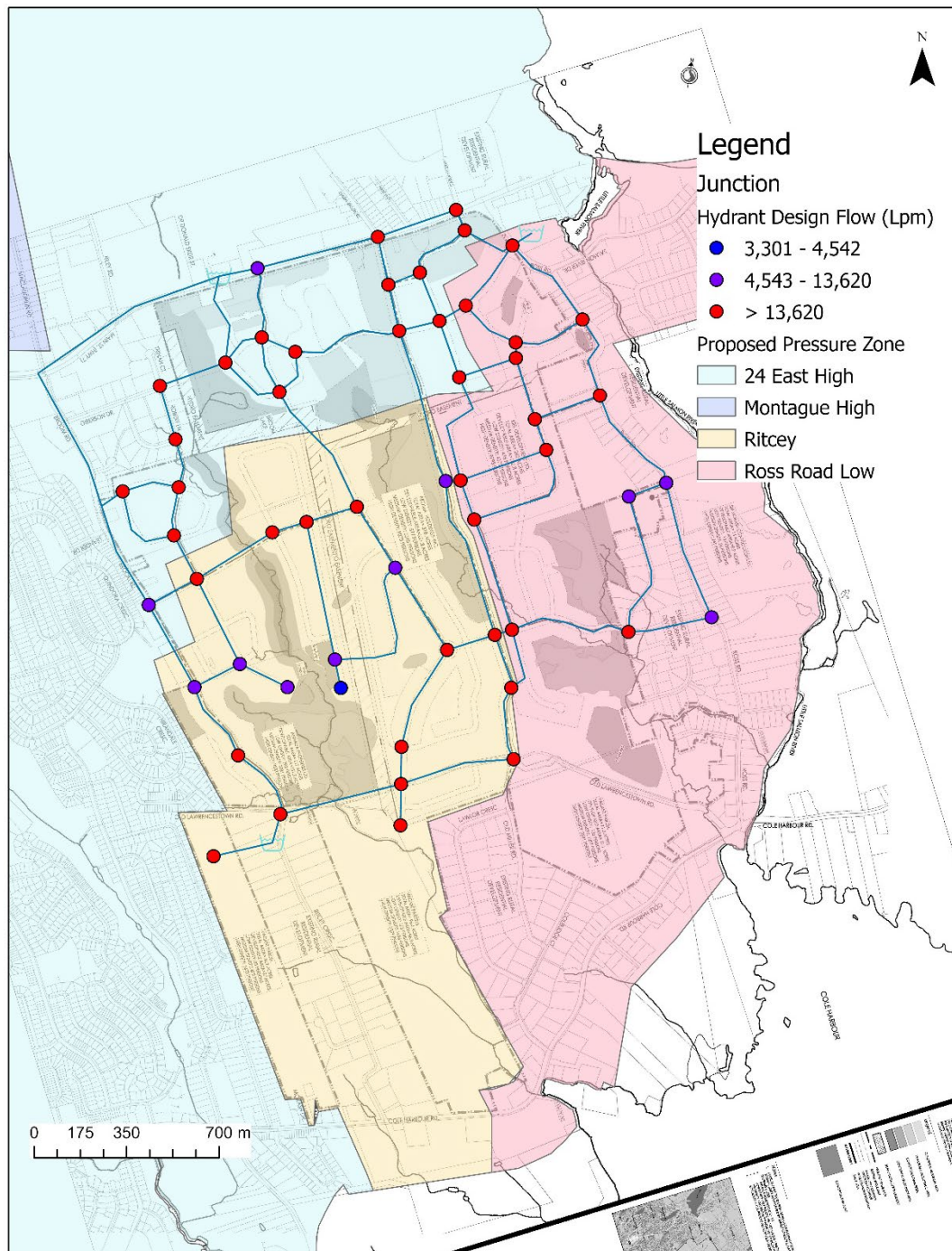


Figure 4-4: Available Fire Flow @ 22 psi under MDD (High-Density Scenario)

4.3 Water Servicing Conclusions and Recommendations

4.3.1 CONCLUSIONS

In the absence of a full regional water model, the water model development assumed that the connection to each existing pressure zone is a constant HGL with unlimited flow (i.e. the connections are modelled as fixed head reservoirs). This assumption does not reflect the actual system, however, in the absence of a full system model it is a reasonable assumption.

The water model results indicate the following for both the high-density and low-density population scenarios:

Flow Scenario	Pressure Range (psi)	Max Velocity (m/s)	Available Fire Flow (Lpm)
MDD High Density	49 – 110	< 1.5	N/A
PHD High Density	48 – 108	< 1.5	N/A
MHD High Density	49 – 110	< 1.5	N/A
MDD + FF High Density	> 22	< 2.4	4,500 - 28,500*
MDD Low Density	49 – 110	< 1.5	N/A
PHD Low Density	49 – 110	< 1.5	N/A
MHD Low Density	49 – 110	< 1.5	N/A
MDD + FF Low Density	> 22	< 2.4	4,500 - 30,000*

* Based on the assumptions of a constant HGL at the connections to the existing pressure zones. Therefore, the values for available fire flow should be considered with a low level of confidence.

Since the maximum pressures for each scenario exceed the range presented in Halifax Water's Design Specification, pressure reducing valves installed on the water service lines (in accordance with Halifax Water's Supplementary Standard Specifications) should be considered in those locations. Alternatively, a new pressure zone, south of Highway 7, may also be considered during the next design phase. It is assumed the new pressure zone would be controlled by a pressure reducing valve from the 24 East High pressure zone.

4.3.2 RECOMMENDATIONS

The presented subdivision plan is preliminary and subject to change, therefore the MHD, MDD, PHD and required FF demands presented in this report may change resulting in changes to proposed water distribution preliminary design. It is recommended that the level of service and distribution system requirements be reassessed during subsequent design stages. Also, during the next stages of design the sizing and placement of regional water infrastructure should be considered.

In the absence of a full system model the effect of the proposed development on the level of service of the remaining system could not be assessed. Also, the effect of potential restrictions within the existing system on the proposed development could not be assessed. In Halifax Water's 2019 IMP, it was recommended that an all-pipe hydraulic model be developed. An all-pipe model can be used to assess fire flow objectives at each property or node in the system. It is recommended that the proposed development be incorporated in the all-pipe model to perform a more refined fire flow level of service assessment for the development.

5 Wastewater Infrastructure

Although not directly indicated in the East Region Wastewater Infrastructure Plan (GM BluePlan, 2019), it is assumed that the development area will ultimately contribute sanitary flows to the gravity pressure main downstream of the Bissett Lake PS. Existing sanitary sewers within Cole Harbour Road and surrounding residential subdivisions are sized to meet only local sanitary contributing flow, and require upsizing should development areas divert sanitary flows through existing sewers to the Bissett Lake PS. Additionally, a sufficiently deep gravity sewer connection does not currently exist to permit connection to gravity mains for the entirety of the development area either within Cole Harbour to the south or Main Street to the north.

In review of preliminary grading for the development area, it was identified that sufficient grade exists to permit construction of network of gravity sewers for the majority of the development contributing area to a low point, and thus a new pump station, at the extension of Kenora Drive. Additional small lift stations are anticipated to be required to service trapped low areas at the extension of Old Lawrencetown Road and adjacent to Cole Harbour to service southerly lands west of the Hydro corridor (Areas R28A, R32A, R33B, R37A, and R40A on **Drawing SA-1**). Discharge from proposed force mains is anticipated to be directed to the downstream Bissett Lake PS. Development lands adjacent to Main Street are anticipated to contribute to a gravity sewer extension along Main Street to the existing downstream Memorial Drive PS. Further contribution to the Memorial Drive PS has been avoided to limit capacity impacts to downstream local sewers in the area.

A network of gravity sanitary sewers has been conceptualized for the development area as indicated on **Drawing SA-1**. Sizing of the gravity sewers has been completed as per Halifax Water design requirements noted in sections above, and based on population estimates for the development area. Design sheets for the gravity sewer segments are included in **Appendix B** and are based on the highest population density scenario.

Table 5-1: Estimated Peak Sanitary Discharge

Development Scenario	Population	ICI Contributing Area (ha)	Total Catchment Area (ha)	Peak Flow (L/s)
Low	1,863	13.48	426.80	167.2
Medium	17,909	13.48	426.80	373.3

High (Developer- Requested)	35,834	13.48	426.80	566.4
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Due to grading constraints in areas adjacent to existing watercourses (particularly on the eastern boundaries of the development area, sanitary sewer depths may exceed the maximum permissible sewer cover of 5.0m. A local sanitary sewer may be proposed at detailed design to run parallel to the deeper sewer segments.

5.1 Implications & Master Plan Alignment

The Wastewater Infrastructure Plan (GM Blue Plan, 2020) identified infrastructure needs to maintain the level-of-service goals for Halifax's existing residents and interests, as well as to maintain these as identified growth occurs. The implications of the FSC growth areas on the Wastewater Infrastructure Plan (WIP) recommendations are thus of interest as these growth areas are in addition to those considered in the 2020 WIP. The FSC growth areas represent a significant increase in the service area considered within the planned growth horizon at the time of the completion of the 2020 WIP. As a result, the additional growth areas to be accommodated would be expected to have an impact on regional infrastructure capacity requirements and their planned upgrades - most notably, the gravity trunk sewer and the EP WWTP.

The 2020 WIP identified several upgrades (Strategy 1c: Enhanced Conveyance) in the collection system upstream of the Eastern Passage (EP) WWTF. These are summarized in **Table 5-2**, and shown on **Figure 5-1** as taken from the 2020 WIP report.

Table 5-2: Eastern Passage Required Projects (taken from 2020 WIP Tables 24 and 25)

Project	Year	Description
Install new pressure-gravity sewer with pump out stations	2020	Required immediately as main capacity restriction in sewershed and triggered by growth.
RDII Reduction Program	2020-2036	Long-term program expected. RDII reduction was started in the Eastern Passage and Loon Lake areas, as it impacts upgrades to Pumping Stations. RDII

Project	Year	Description
		reduction in the Cole Harbour area is delayed due to staggering the program and no growth in the area. However, RDII reduction in Cole Harbour area is scheduled to occur before upgrades to Bisset Lake PS are initiated.
Upgrades to Quigley's Corner Pumping Station and Pumping Station Optimization	2021-2026	Required after RDII Reduction program is completed in EP area, as it will reduce flows to Quigley's Corner PS and upgrades required to remove spills.
Upgrades to Memorial Drive Pumping Station	2031-2036	Required after RDII Reduction program is completed in Loon Lake area, as it will reduce flows to Memorial Drive PS and upgrades required to remove spills.
Linear upgrades (Forest Hills Parkway, Colby Drive and Caldwell Road)	2031-2046	Local linear upgrades are predominantly to resolve existing issues flagged in the wastewater hydraulic model; however, field verification should be completed to determine how soon these projects will be required.
Upgrades to Beaver Crescent Pumping Stations	2036-2041	Upgrades to Beaver Crescent Pumping Station forcemain were underway in 2020. Initiate after upgrades on Beaver Crescent

Project	Year	Description
		PS forcemain are complete and new pressure-gravity sewers are installed with forcemains reconnected.
Upgrades to Caldwell Road Pumping Station	2039	Required after upgrades along Caldwell Road to remove flow restrictions upstream of the Pumping Station and triggered by growth in the Morris Lake development.
Upgrades to Bissett Lake Pumping Station	2041	Upgrades to Bissett Lake Pumping Station are impacted by numerous projects, including the installation of the pressure-gravity sewers downstream to remove flow restrictions and RDII reduction in catchments upstream of the Pumping Station.
Decommission asbestos pressure-gravity sewer	2043	Decommissioned after new pressure-gravity sewer is installed and operational.

The 2020 WIP does not mention the extent of capacity restrictions associated with the deficiencies identified, nor the capacity gained through the recommended upgrades.

The 2020 WIP also identifies that there were ongoing odour issues due to long retention times in the pressure-gravity system. The high priority for the upgrade of that system aligned with these issues.

Refer to **Figure 5-2** for an overview of how the Westphal lands are envisioned to connect to the existing HRM collection system.

5.1.1 CONVEYANCE IMPACTS

The most significant impact from the Westphal lands on the conveyance upgrades identified in the 2020 WIP would be on the pressure-gravity system and the Bisset Lake PS and storage facility. This system collects flow from a large area and a number of pump stations before discharging downstream towards the EP WWTF. Additional considerations for the Westphal lands on the conveyance system include the impacts on the linear infrastructure between Bisset Lake PS and Caldwell Road PS, as well as the Memorial Drive PS and Bisset Lake PS. These linear upgrades were identified as needed between 2031-2046 in the 2020 WIP. It may be feasible to incorporate the Westphal lands contribution in these upgrades, however the magnitude of the flows may trigger other options as being more favorable. Additional hydraulic and financial assessment is recommended to confirm.

It will be important to confirm that added flow from the Westphal lands can be accommodated within the existing and planned configurations for the pressure-gravity system and planned upgrades at other facilities. We estimate that the design wet weather flow from Westphal reaches upwards of 566L/s. Combined with the design wet weather flow from Morris Lake (368L/s), an additional 934L/s can be expected. That is, the Bisset Lake PS would see the full contribution from Westphal, and the EP WWTF would see the combined contribution from Westphal and Morris Lake.

As discussed further in Section 5.1.3, this consideration merits the use of the City's updated hydraulic model assessed in context of regional servicing needs within the framework of the IMP. This includes alternatives evaluations to determine a preferred regional servicing and infrastructure upgrades strategy that best accommodates the broader needs and goals of the HRM and HW. This note is also applicable to the Morris Lake FSC lands interest and the cumulative impact of both these growth areas should be considered.

5.1.2 PUMP STATION AND WWTF IMPACTS

The Westphal lands will need to be serviced by 3 pumping stations within the development. These will discharge into the upper portion of the EP WWTF catchment and impact the flows seen at several existing pumping stations, including:

- Memorial Drive PS
- Stratford Dr PS
- Bissett Lake PS
- Caldwell Rd PS

Additionally, there are surge/holding tanks present at the Bissett Lake PS and Caldwell Rd PS. The availability and planned use of the volumes provided at these locations warrants review in consideration of the Westphal forecasted contributions.

Also of note, upgrades at the Memorial Drive PS (2031-2036), Caldwell Road PS (2039), and Bissett Lake PS (2041) should be reviewed for adequacy if the Westphal lands progress and connect as identified in this FSC consideration.

Furthermore, the range of potential flows from the Westphal lands has the potential to significantly surpass the available capacity at the Bissett Lake PS. Specific attention and further consideration at this location is warranted as part of the development planning to accommodate the Westphal lands and other growth interests. The timing requirements and/or sizing needs may be impacted. Additional hydraulic and financial assessment is needed to confirm.

Ultimately the Westphal lands would be conveyed using the existing pressure-gravity system to the EP WWTF. As such, the planned upgrade of the gravity-pressure sewer and any infrastructure at the EP WWTF should be revisited to ensure it can accommodate the additional flow from the Westphal lands. We estimate that the design peak daily dry weather flow from Westphal may reach upwards of 367L/s. Combined with the design peak daily dry weather flow from Morris Lake (294L/s), an additional 661L/s can be expected.

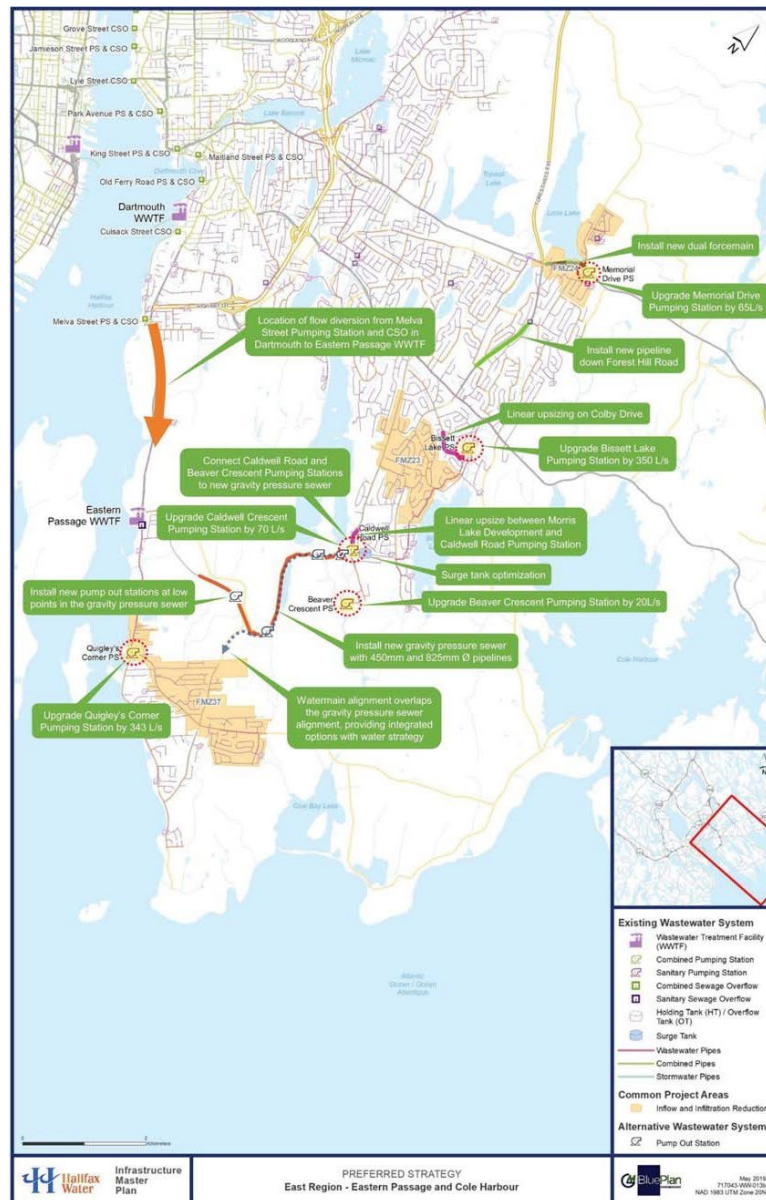


Figure 5-1: Eastern Passage East Region Preferred Servicing Strategy (GM BluePlan, 2020).

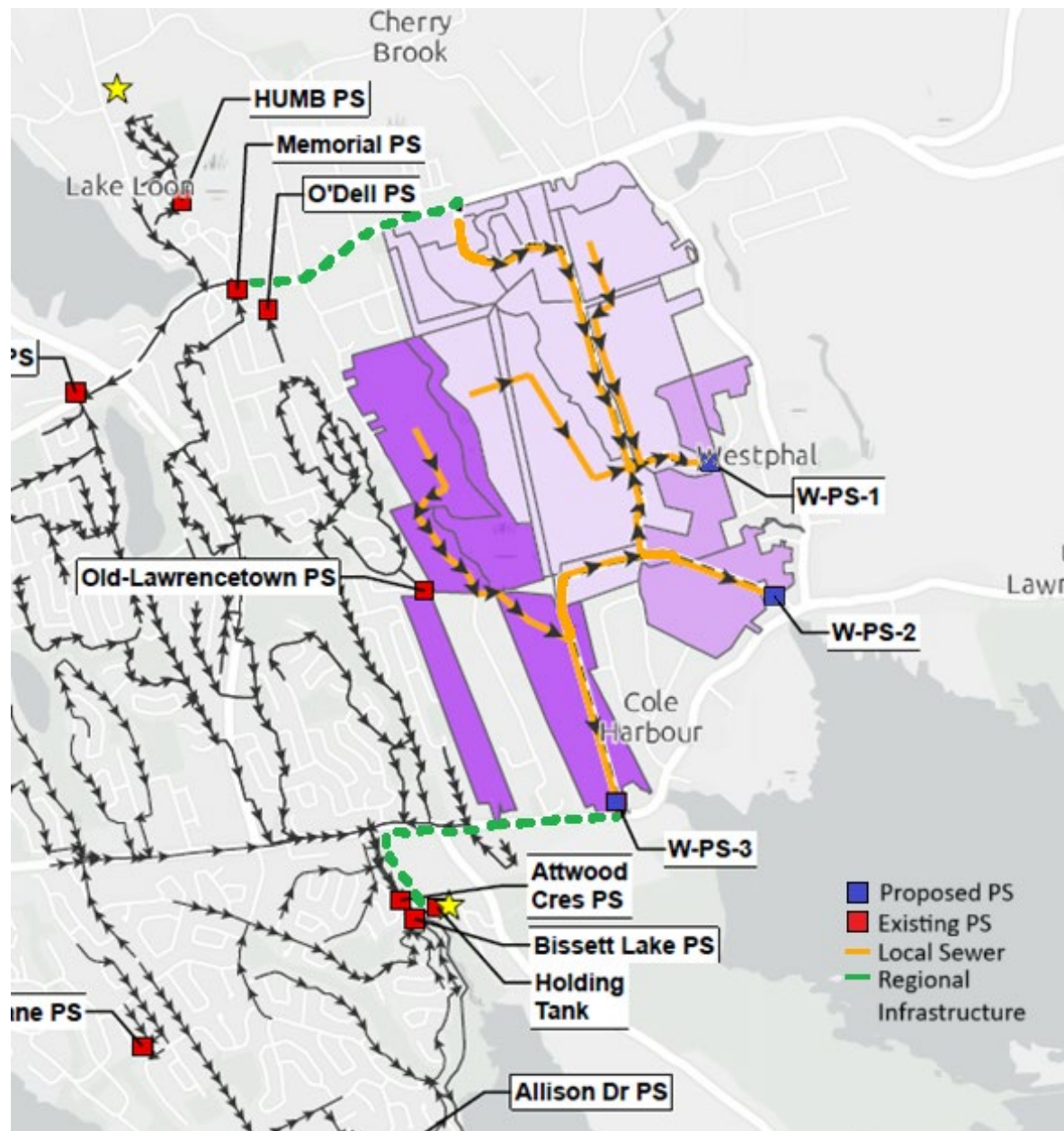


Figure 5-2: Westphal Wastewater Servicing

5.1.3 ADDITIONAL WASTEWATER SERVICING STRATEGIES OF NOTE

The conveyance and pump station / WWTF impacts presented explore how the Westphal lands could integrate into the wastewater servicing strategy that was recommended in the 2020 WIP. Other servicing strategies exist however that merit consideration. The 2020 WIP explored several high-level approaches. The assessed strategies included replacing the pressure-gravity servicing strategy with a range of large trunk sewer tunnelling alignments. These tunnelling alternatives provide the benefit of allowing several existing pumping stations to be ultimately decommissioned in the sewershed upstream of the EP WWTF.

Other items of note with the tunnelling strategies include the mitigation of existing identified odour issues that accompany the pressure-gravity system, as well as potential mitigation of required storage volume expansions and prescribed pumping station capacity upgrades. There are a range of tunnel alignments that were considered feasible in the 2020 WIP, and these included options that saw the tunnel cross through the Shearwater DND property. A transition from pressure-gravity to a deeper tunnel could also be implemented in a phased approach, where the trigger to proceed would consider the ability to expand/upgrade existing infrastructure.

Specific to the Westphal growth area, it is possible that a tunnel alternative could be introduced at a deeper alignment that would remove (or significantly reduce) the requirements for pump stations to service the growth area. Considering there are numerous existing pumping stations and storage/holding tanks downstream from the Westphal area, decommissioning these after a deeper tunnel servicing option is introduced provides an opportunity for significant operational and maintenance savings. The cost effectiveness and benefits of such a solution could potentially be enhanced when considering a potential need to accommodate servicing within both the Westphal and Morris Lake areas.

Additional evaluation would be required to update the 2020 WIP findings for these tunnel servicing considerations. There are existing constraints that may or may not have been addressed through upgrades to existing pumping station conveyance capacities and wet weather storage availabilities. Introducing a deep tunnel is a significant financial investment and understanding the timeline for the required implementation warrants extensive study. The evaluation of preferred tunnelling alignment warrants renewed consideration considering the extent of the upstream growth considered in this study.

We recommend that HW and HRM revisit the technical and financial evaluations of the servicing strategy for the EP WWTF. A cost-benefit analysis would enhance the confidence that the implemented servicing strategies to come are best aligned with HW and HRM priorities, while maintaining (or enhancing) service to existing residents and proactively planning those infrastructure upgrades required to maintain this same level of service to future growth areas. Such an analysis would align well within the context and scope of an IMP update.

6 Grading

The objectives of the grading design strategy are to identify the elevation range requiring potable water servicing, estimate wastewater collection points, satisfy the stormwater management requirements, adhere to permissible grade raise restrictions where possible for the development area, and provide for minimum cover requirements for storm and sanitary sewers. The grading design also follows any recommendations outlined in the Infrastructure Master Plan where possible, and endeavors to provide an overland route to existing watercourses as described in Stantec's *Westphal Watershed and Stormwater Study – Final Report* (2025).

Preliminary grading has been set at conceptual road centerline, with a minimum overland flow slope of 0.1% from high point to high point. Grading endeavours to maintain a road longitudinal slope less than 3% in the majority of development areas to facilitate driveway access and limit requirements for retaining walls at future internal property lines. Tie-ins to existing surrounding Rights-of-Way have been respected based on high level topography as obtained by provincially sourced LiDAR.

Development setbacks should be established based on the worst-case scenario between the regulatory 100-year floodplain, the meander belt width of the watercourse, aquatic setback limit of 15 meters from top-of-bank or 30 meters from normal high water marks whichever is greater; and the slope stability setback.

Based on the above, it is recommended that no active development be permitted within the limits of the 100-year regulatory floodplain. Some reduced-risk uses, such as recreational sports fields and trails, may be considered. This is subject to design considerations that effectively mitigate and/or minimize the impact of such development on the floodplain and protect the riparian corridor functions.

Moreover, any proposed development should adhere to the constraints identified in the LSA constraint mapping. This includes areas of significant wildlife habitat, wetlands, steep slopes, and other environmentally sensitive areas. In areas where development is proposed within or in proximity to the identified floodplain, suitable mitigation measures should be implemented.

Within the Westphal development specifically, highly sloped areas are noted under existing conditions in proximity to eastern development boundary at Ross Road. It is likely that retaining walls will be required to facilitate development and tie-in to surrounding roadways without heavy deviation from current elevations of nearby watercourses.

The conceptual Grading Plan for the development area is indicated on **Drawing GP-1 in Appendix C**.

7 Preliminary Costing

The scope of work for this project involves costing of infrastructure upgrades. Since many servicing projects would be associated with road improvements, the costing can be found in the Westphal Area Summary Report and coordinated with the transportation conclusions.

APPENDICES



Appendix A Potable Water Infrastructure





**HALIFAX REGIONAL MUNICIPALITY
FUTURE SERVICED COMMUNITIES –
WESTPHAL WATER SERVICING PLAN**
Final Report

March 31, 2025

Prepared for:
Halifax Regional Municipality

Prepared by:
Stantec Consulting Ltd.

Project Number:
160410459

Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan

Revision	Description	Author	Date	Quality Check	Date	Independent Review	Date
0	Water Servicing Plan Technical Memo	JB	2024-05-07	JS	2024-05-10	DT	2024-05-10
1	REV1	JB	2024-09-27				
2	Final	JB	2025-3-31			DT	2025-04-02



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan

The conclusions in the Report titled Halifax Regional Municipality Future Serviced Communities - Westphal Water Servicing Plan are Stantec's professional opinion, as of the time of the Report, and concerning the scope described in the Report. The opinions in the document are based on conditions and information existing at the time the scope of work was conducted and do not take into account any subsequent changes. The Report relates solely to the specific project for which Stantec was retained and the stated purpose for which the Report was prepared. The Report is not to be used or relied on for any variation or extension of the project, or for any other project or purpose, and any unauthorized use or reliance is at the recipient's own risk.

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1 Introduction

The Halifax Regional Municipality (HRM), through their Regional Municipal Planning Strategy (Regional Plan), have identified four Future Serviced Communities which require a comprehensive neighbourhood planning process that includes a review of existing servicing infrastructure capacity and constraints. The four study areas are as follow.

- Sandy Lake
- Highway 102 Corridor
- Eastern Passage (identified as Morris Lake in the RFP)
- Westphal (identified as Akoma Lands in the RFP)

This report outlines the results from the review of the potable water servicing within the Westphal Development area and summarizes the conceptual water servicing plan required to meet the established level of service and design criteria.

2 Level of Service and Design Criteria

The following resources were used to define the level of service and design criteria for potable water servicing:

- Halifax Water's Design Specifications (June, 2023)
- Halifax Water's Water Infrastructure Servicing Plan Final Report Volume 2 of the Infrastructure Master Plan
- Halifax Water's Regional Pressure Zone Map: West-Central-East (Map Issued April 2023)

2.1 Halifax Water Design Specifications

The Halifax Water Design Specifications was reviewed, and the following items were noted for use in the preliminary water distribution designs:

- Water System extensions must be carried out in conformance with a Water Master Plan.
- Water distribution systems are to be designed to accommodate the greater of Maximum Day Demand plus fire flow demand (MDD + FF), or Peak Hour Demand (PHD).
- Design to be supported by a hydraulic analysis to determine flows, pressures and velocities under Maximum Day Demand plus fire flow demand, Peak Hour Demand and Minimum Hour Demand conditions, describing any impacts on the existing system.



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan 2 Level of Service and Design Criteria

However, without access to the regional water model the potential effects of a proposed design to the existing system cannot be assessed.

- The analysis is to begin at a location of known hydraulic grade and include demands on the existing system downstream of the known hydraulic grade line, as well as demands generated by the proposed development. Hydrant flow test(s) are to be conducted to confirm the static hydraulic grade line and determine the system curve and available residual pressure at the boundaries of the analysis.
- Hazen Williams 'C' values to be used for the design of water distribution systems, regardless of pipe material, will be:

Table 2-1: Friction Factors from Halifax Water Design Specifications

Diameter of Water Main (mm)	'C' Factor
150	100
200 to 250	110
300 to 600	120
Larger than 600	130

- Estimated fire flow requirements as shown in the table below:

Table 2-2: Fire Flow Requirements

Land Use	Fire Flow (Lpm)	Duration (hrs)	Number of Fire Hydrants
Single Unit Dwellings	3,300	1.5	1
Two Family Dwellings	3,300	1.5	1
Townhouse	4,542	1.75	1
Multi-unit high rise	13,620	3	3
Commercial	13,620	3	3
Industrial	13,620	3	3
Institutional	13,620	3	3

- Maximum pipe velocity is not to exceed the following:

Table 2-3: Maximum Pipe Velocity

Flow Condition	Max Velocity (m/s)
Peak Hour Demands	1.5
Fire Flow	2.4

- Minimum watermain size:



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan 2 Level of Service and Design Criteria

- 200 mm for local distribution watermain
- 300 mm for feeder mains
- Allowable pressure range:
 - ADD and MDD: 50 – 80 psi
 - Minimum Hour (MHD) and PHD: 40 – 90 psi
 - MDD + FF: > 22 psi
- The per capita average day demand (ADD) is 375 L/per/day.
- The peaking factors used to calculate MHD, PHD and MDD must be based on:
 - Historical information
 - Nova Scotia Environment guidelines, or
 - As directed by the Engineer

Where the proposed development requires a booster station, PRV or storage, peaking factors shall be determined in consultation with the Engineer.

Table 2-4: Peaking Factors

Land Use	Minimum Hour	Maximum Day	Peak Hour
Low Density Residential	0.70	1.65	2.50
High Density Residential	0.84	1.30	2.50
Industrial	0.84	1.10	0.90
Commercial	0.84	1.10	1.20
Institutional	0.84	1.10	0.90

2.2 Halifax Water IMP Volume 2

The following items from the IMP volume 2 were noted for use in the preliminary water distribution design:

- Overview of existing water system network
- Existing Pockwock and Lake Major Distribution Systems Schematic
- Proposed projects to enhance system resiliency (if any)

2.3 Halifax Water's Regional Pressure Zone Map

Halifax Water provided a copy of the Regional Pressure Zone Map: West-Central-East (Map Issued April 2023). The pressure zone map was used to determine the hydraulic grade line of potential connection points for the proposed development area.



3 Proposed Development

3.1 Site Location

The Westphal study area is located east of Dartmouth and Cole Harbour. The area is bounded by Highway 7 to the north, Robert Lane and Broom Road on the west, and Ross Road to the east. Coleridge Estates, a small community predominantly comprised of single-detached homes, lies to the south. The proposed development area totals approximately 415 hectares of largely undeveloped land.

3.2 Adjacent System Description

The proposed Westphal development is located adjacent to the Ross Road Low, Ritcey Low, and 24 East High pressure zones. These pressure zones are included in the Lake Major system and are serviced by the Lake Major Water Treatment Facility.

The hydraulic grade lines (HGL) of the adjacent pressure zones are summarized in the following table and illustrated in **Figure 3-1**.

Table 3-1: Adjacent Pressure Zones Hydraulic Grade Lines

Pressure Zone	HGL (ft)	HGL (m)
Ross Road Low	233 - 242	71 - 74
Ritcey Low	290 - 300	88 - 91
24 East High	380 - 390	116 - 119



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan

3 Proposed Development

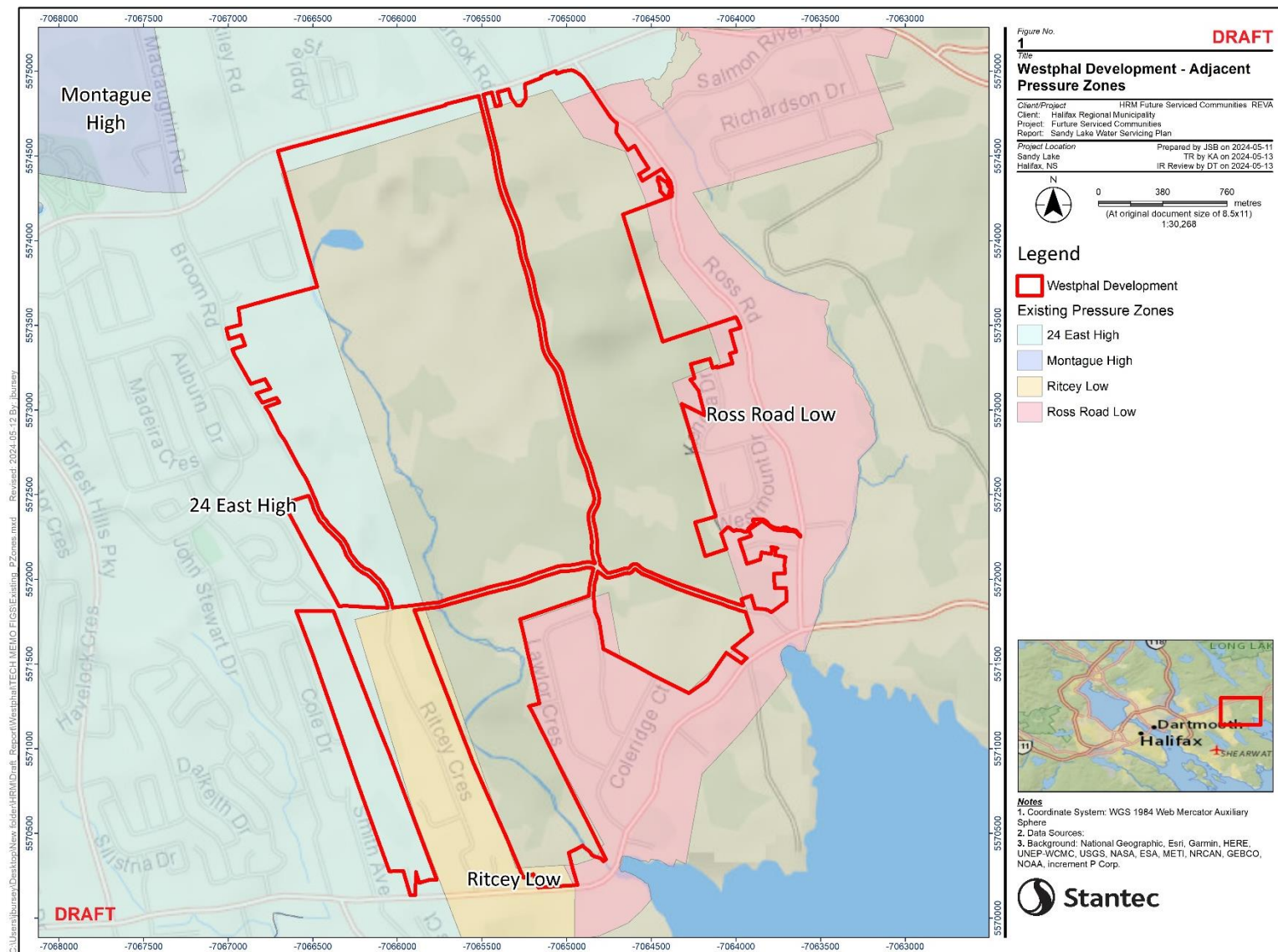


Figure 3-1: Westphal Development - Adjacent Pressure Zones



3.3 Proposed Development

3.3.1 GRADING

The proposed grading plan (street level) for the Westphal development ranges from approximately 25 m toward the east (near Ross Road) to 60 m near Broom Road (**Figure 3-2**).

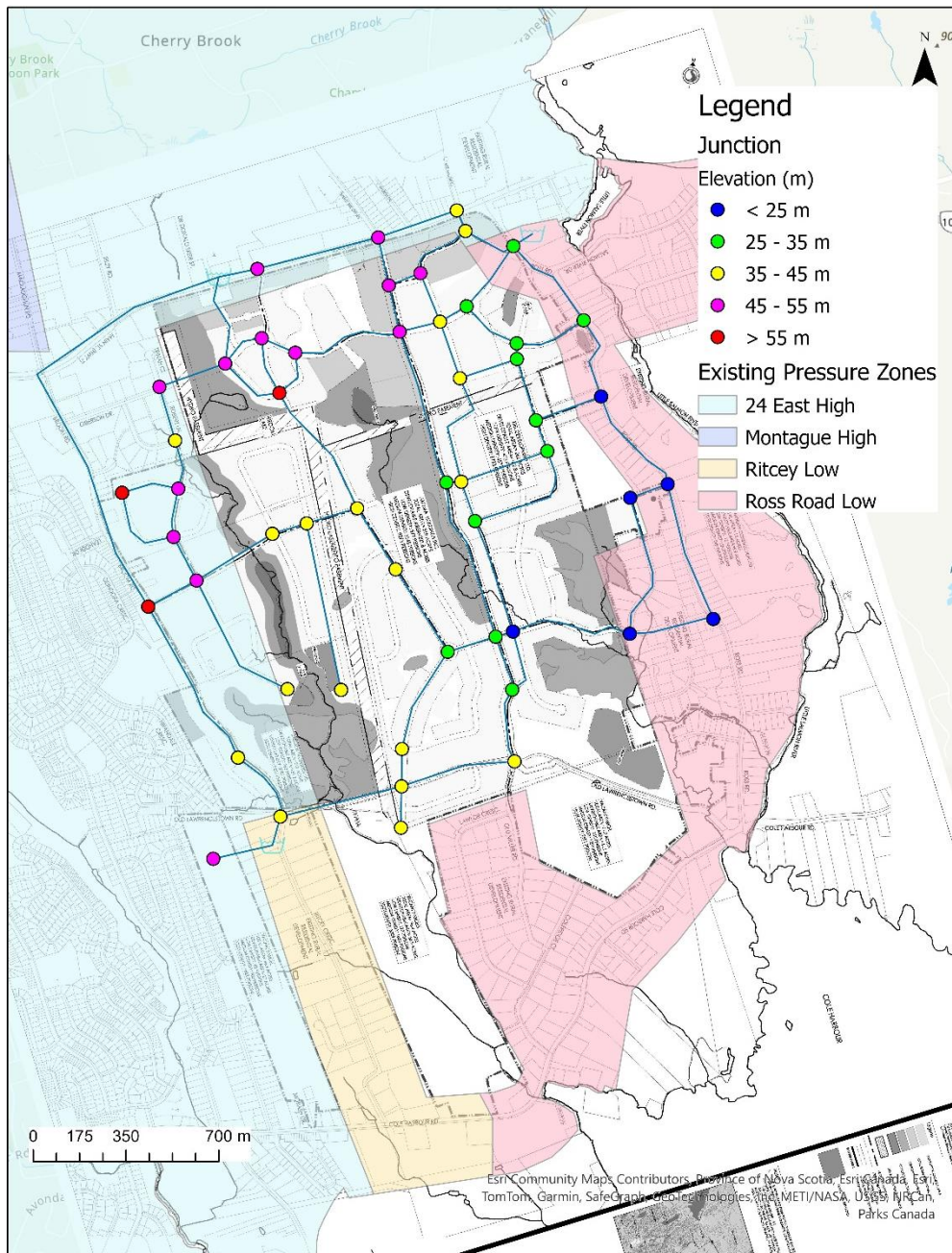


Figure 3-2: Proposed Site Grading



3.3.2 HYDRAULIC GRADE

Halifax Water's water system level of service pressure range is 50 – 80 psi for ADD and MDD and 40 – 90 psi for PHD and MHD. Given the hydraulic grade line of the adjacent pressure zones, the serviceable range of elevations within those pressure zones are presented in **Table 3-2**. Comparing the serviceable elevation ranges to the development elevation ranges indicate that the proposed re-delineation of the Ross Road Low, Ritcey Low, and 24 East High pressure zones can accommodate the development from a pressure perspective. The proposed pressure zone re-delineation is illustrated in **Figure 3-3** and connection points are presented in **Figure 3-4**. Isolation valves, used to separate the pressure zones, are mimicked in the model by “closing” pipes.

Table 3-2: Serviceable Range per Pressure Zone (From 40 to 90 psi)

Pressure Zone	HGL (m)	Serviceable Elevation (m)*	
		Low	High
Ross Road Low	71 - 74	8 – 11	43 - 46
Ritcey Low	88 - 91	25 - 28	60 – 63
24 East High	116 - 119	53 - 56	88 - 91

* Neglecting friction loss

Hydrant flow tests were conducted on Broom Road, Highway #7 (Main Street) near Westphal Way, Ritcey Crescent and Ross Road near Highway #7 to confirm the static pressure of the connecting pressure zones near the proposed connection points. The test results are presented in **Appendix A**. The static pressures reported during the tests are presented in **Table 3-3**. The approximate ground elevation at each test location and resulting HGL at each test location are also presented in **Table 3-3**. As shown in the table above, a HGL of 116 m for the 24 East High pressure zone aligns with the HGL's recorded at test numbers 1, 2 and 4, and a HGL of 88 for Ritcey Low pressure zone is in line with the test #3.

Table 3-3: Summary of Static Pressures Recorded

Test #	Test Location	Static Pressure (psi)	Approx. Ground Elevation (m)	HGL (m)
1	Broom Road	79	61	116.6
2	Highway #7 near Westphal Way	92	52	116.8
3	Ritcey Crescent near cul-de-sac	70	39	88.3
4	Ross Road near Highway #7	111	38	116.2



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan

3 Proposed Development

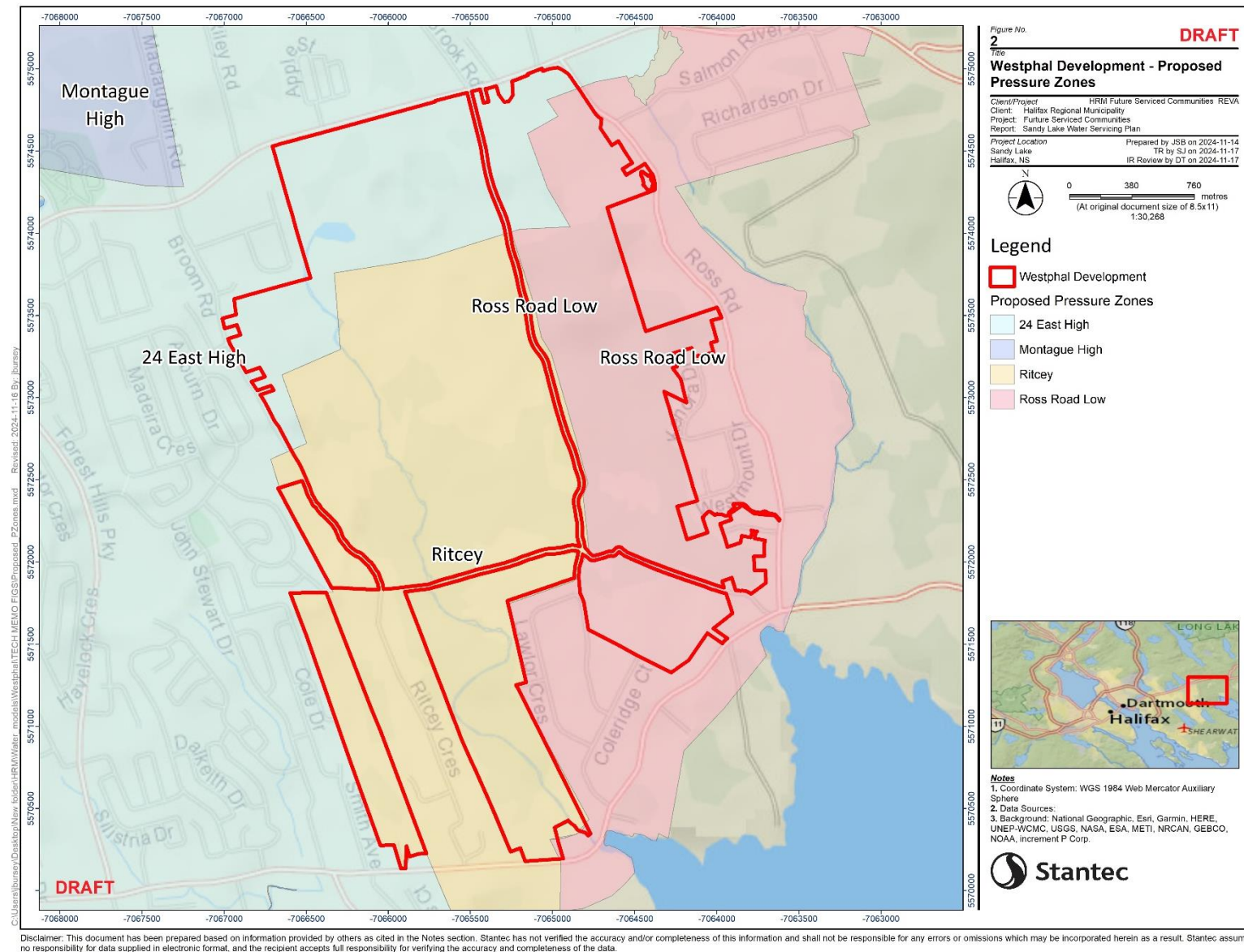


Figure 3-3: Westphal Development - Proposed Pressure Zone Re-Delineation



3.3.3 DEMANDS

Various development scenarios were prepared, considering different land uses/building types to estimate potential population. Populations corresponding to high- and low-density scenarios are described in Section 2 of Stantec's *Halifax Regional Municipality Future Serviced Communities Volume 2: Westphal Study Area*, and presented in **Table 3-4**. The corresponding demands are presented in **Table 3-5**. Peaking factors per Halifax Water's Design Specification (**Section 2.1**) were applied to estimate MHD, MDD and PHD. Since the high-density scenario assumed a range of dwelling types (single, stacked townhomes and multi-unit) blended peaking factors were used for MHD and MDD. However, for the low-density scenario only single unit dwellings were considered and therefore the low-residential density peaking factors for MHD, MDD and PHD scenarios per **Table 2-4** were used to estimate demands for the low-density scenario. A peaking factor of 2.5 was used for the PHD peaking factor for both the high- and low-density scenarios.

Table 3-4: Population Estimates

Scenario	Population
High Density	35,821
Low Density	1,863

Table 3-5: Proposed Demands

Scenario	ADD (Lpm)	MHD (Lpm)	MDD (Lpm)	PHD (Lpm)
High Density	9,332	7,791	12,251	23,330
Low Density	485	339	800	1,212

3.3.4 WATER MODEL

A steady state water network model of the proposed development was built in Innovyze InfoWater Pro 3.5 to assess distribution system requirements within the development to accommodate the MHD, MDD, PHD and MDD+FF demands for the high-density and low-density scenarios. Per the criteria outlined in **Section 2** water distribution systems are to be designed to accommodate the greater of MDD + FF, or PHD. Reservoirs with fixed head equal to the pressure zones' HGL were used to simulate the connections to the existing Ross Road Low, Ritcey Low, and 24 East High pressure zones. Modelling the existing system in this manner does not reflect the actual system, as it assumes the connecting points are always at a constant HGL, regardless of demand scenario, and that there is an unlimited supply of water from the zone. However, in the absence of a full system model it is reasonable assumption. The distribution system within the development was edited to achieve the level of service as described in **Section 2**. Currently, the three pressure zone extension areas are modeled as being serviced by single feeds. However, it is anticipated that during detailed design/construction, the watermains within the new serviced area will be connected and isolation valves and/or pressure reducing valves (PRV) used to maintain the



pressure boundaries. Such design allows for redundancy; in the event of a watermain break the pressure zone boundary valve(s) can be opened and act as a secondary feed until repairs to the watermain can be made. Isolation valves, used to separate the pressure zones, are mimicked in the model by “closing” pipes.

The existing watermains in Main Street, Ross Road and Ritcey Crescent are 300 mm, 250 mm and 300 mm diameters, respectively. Assumed points of connection to the existing pressure zones are presented in **Figure 3-4**.

3.3.4.1 High-Density Population Scenario

Figure 3-4 illustrates the distribution of MDD for the high-density scenario throughout the model. The demands were distributed by density of development proposed, and generally (coarsely) placed at the nodes with the highest ground elevation. Placing the demands at the higher elevations is considered conservative from a hydraulics perspective, as the pressure at these nodes will account for headlosses resulting from the total demand and hence will be the lowest in their local areas. **Figure 3-5** presents the anticipated corresponding pressures throughout the development during MDD, which range from 49 psi (which falls just outside of the required pressure range) to 110 psi, within the development. In general, the pressures in the 24 East High development exceed the range specified for MDD. However, from hydrant tests #2 and #4 (**Table 3-3**) pressure along Highway 7 within 24 East High pressure zone already exceed 80 psi. Servicing this area through Ritcey Low pressure zone was also examined. However, assuming the HGL of Ritcey Low is at the low end of the range (88 m), the highest serviceable elevation (maintaining 50 psi) is approximately 53 m (neglecting friction loss). Since the proposed ground elevations in the area are generally 50 – 55 m it was determined that the Ritcey Low zone cannot service the area. In locations where pressure exceeds 80 psi, pressure reducing valves installed on the water service lines (in accordance with Halifax Water’s Supplementary Standard Specifications) should be considered. Alternatively, a new pressure zone, south of Highway 7, may also be considered during the next design phase. It is assumed the new pressure zone would be controlled by a pressure reducing valve from the 24 East High pressure zone.

Figure 3-5 also illustrates the proposed watermain sizes which range from 200 mm to 450 mm diameter, with the majority being 300 mm diameter. For this scenario, all pipe velocities are less than 1.5 m/s (in accordance with Halifax Water’s Design Specifications).

The distribution of PHD is illustrated in **Figure 3-6**, and the results of the PHD analysis are presented in **Figure 3-7**. Pressures under the PHD scenario range from approximately 48 psi to 108 psi near the division of Ross Road Low and 24 East High pressure zones. The maximum velocity for the PHD scenario is less than 1.5 m/s throughout the proposed system.

MHD were also simulated, the distribution of MHDs and the resulting pressures are presented in **Figure 3-8** and **Figure 3-9**, respectively. Pressures under the MHD scenario range from approximately 49 psi to 110 psi.



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan

3 Proposed Development

As shown for the MHD, MDD and PHD, some locations have pressures greater than that specified in the Design Specification. In these instances, pressure reducing valves installed on the water service lines (in accordance with Halifax Water's Supplementary Standard Specifications) should be considered.

Fire flow analysis in InfoWater Pro returns the flow available at each hydrant while maintaining residual pressure of 22 psi throughout the system and not exceeding pipe velocities of 2.4 m/s. The fire-flows required per Halifax Water's Design Specification vary by land use type as described in **Section 2**. The required fire-flows are presented in **Figure 3-10**. The total MDD + FF demand at each node is presented in **Figure 3-11**, and the results of the fire analysis are presented in **Figure 3-12**. The available fire flow range is approximately 4,500 Lpm to 28,500 Lpm and meets or exceeds the total MDD + FF demands. However, it is important to note that these results are based on the assumptions of a constant HGL at the connections to the existing pressure zones and therefore should be considered with caution. Without a full system model, it is unknown if the system can really provide the fire flows presented. Therefore, it is recommended to examine the development's effect on the entire system by using a full (calibrated) system model (including any upstream improvements/upgrades required within the existing system due to the addition of these lands). However, such model development is beyond the scope of this study. Hence the pressures and available fire flows presented in the report should be considered preliminary.



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan 3 Proposed Development

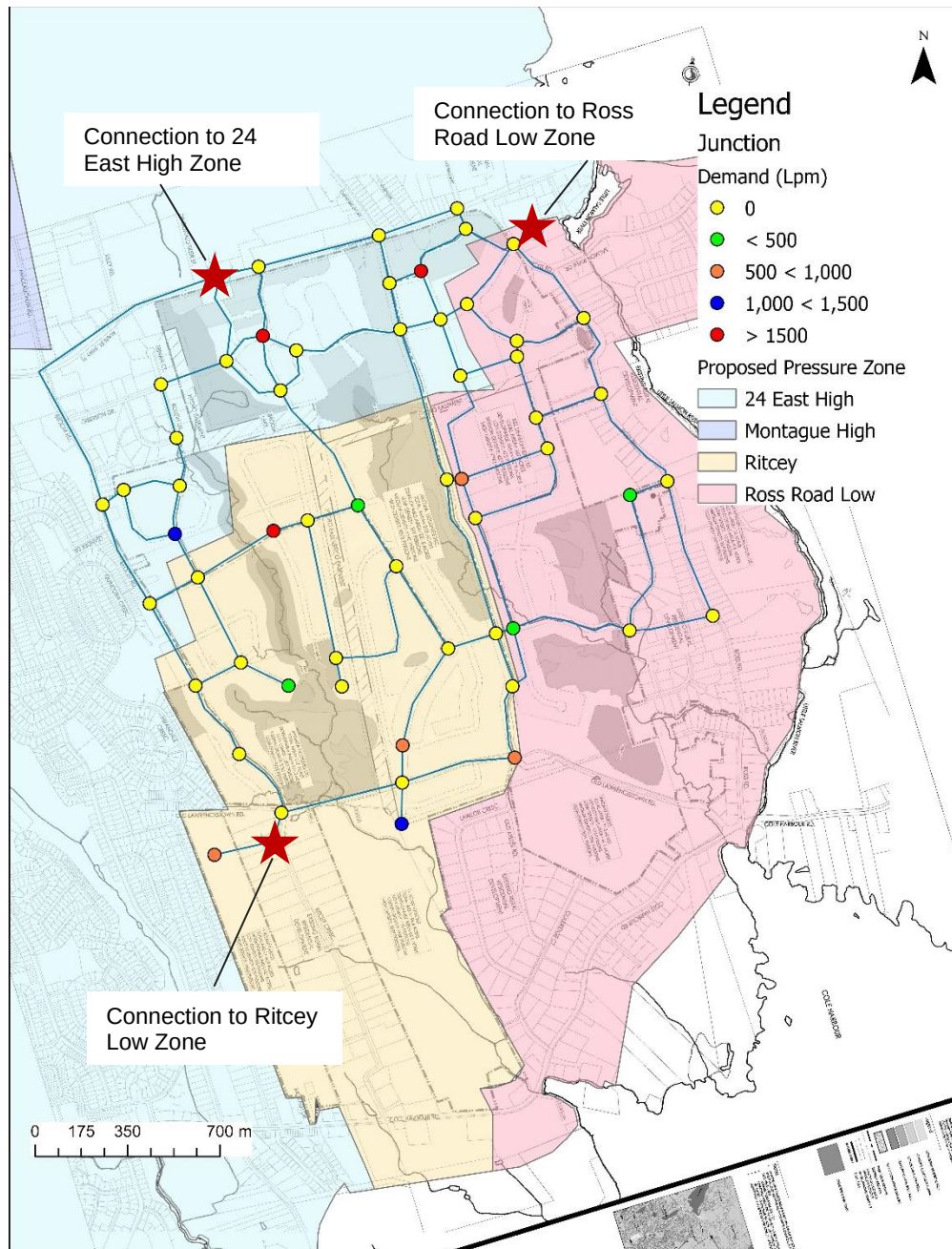


Figure 3-4: MDD Distribution (High-Density Scenario)



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan 3 Proposed Development

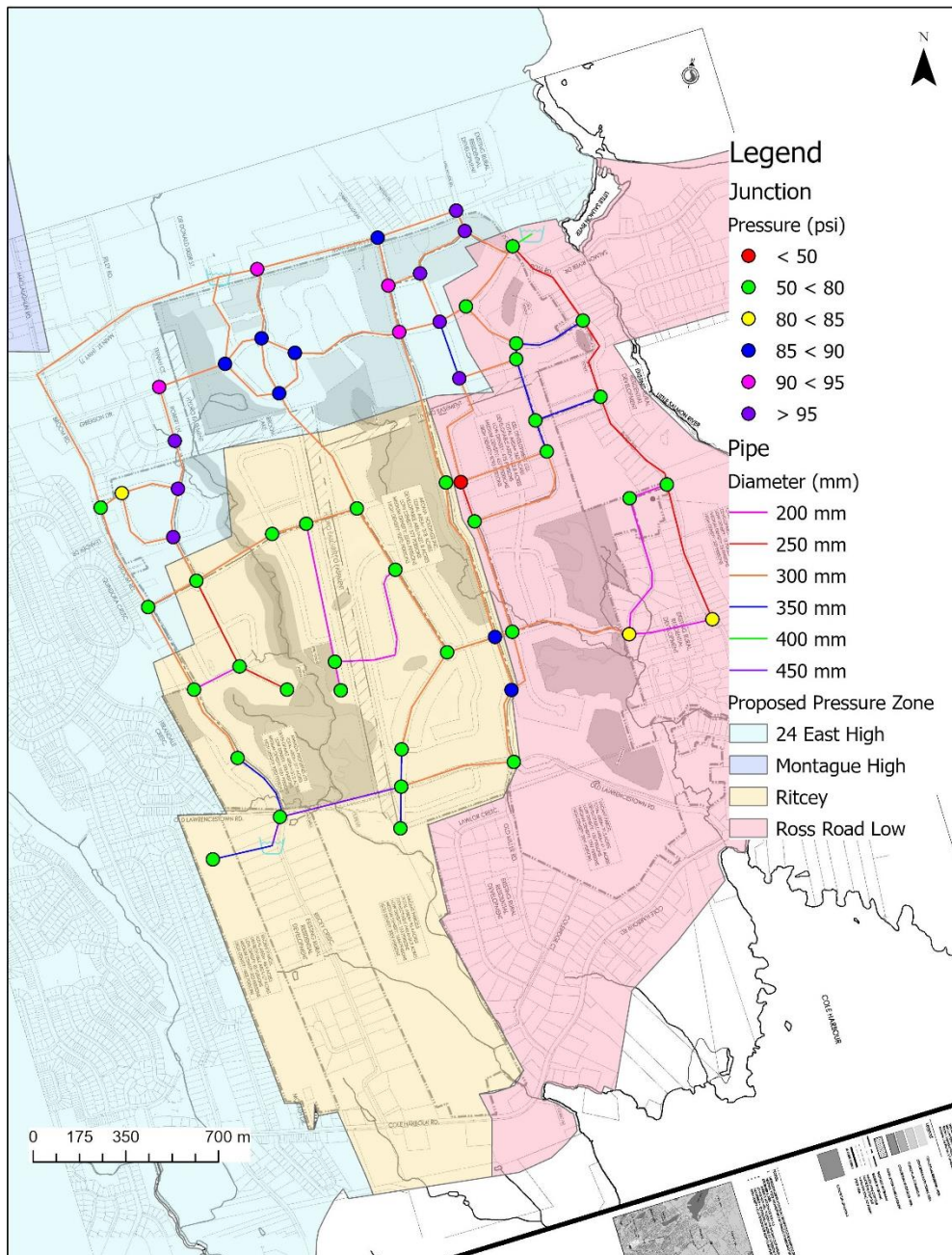


Figure 3-5: Pressure Distribution Under MDD (High-Density Scenario)



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan 3 Proposed Development

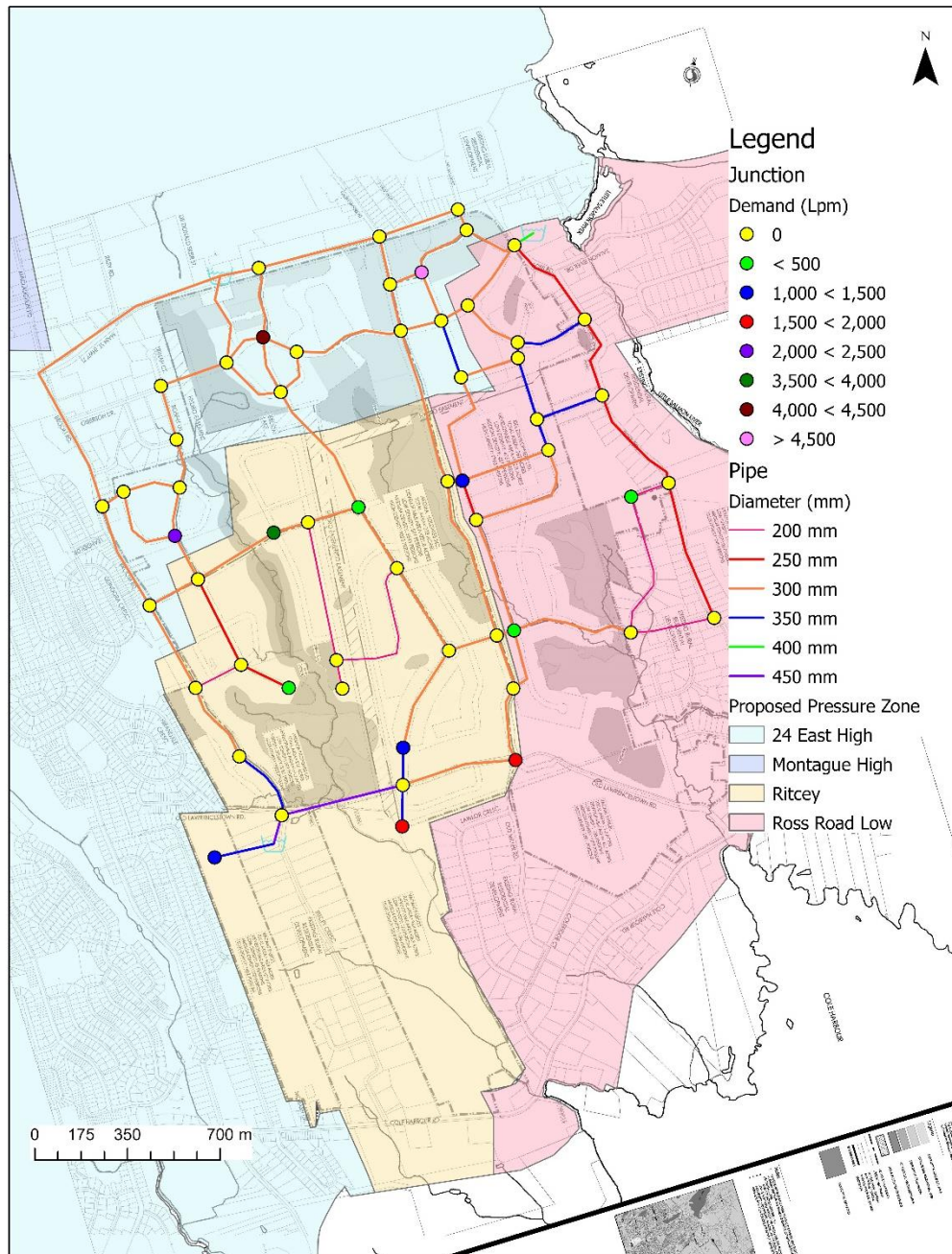


Figure 3-6: PHD Distribution (High-Density Scenario)



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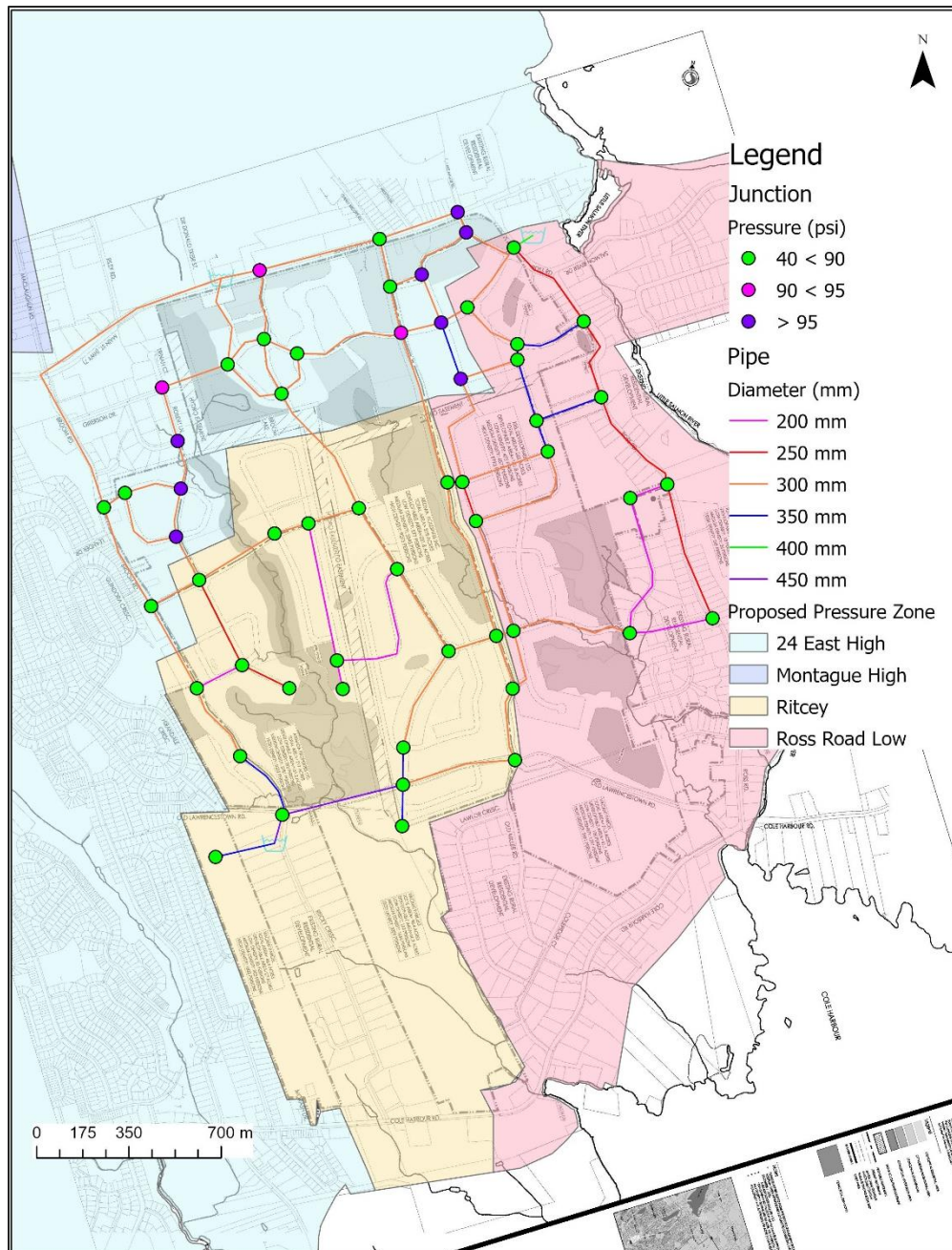


Figure 3-7: Pressure Distribution Under PHD (High-Density Scenario)



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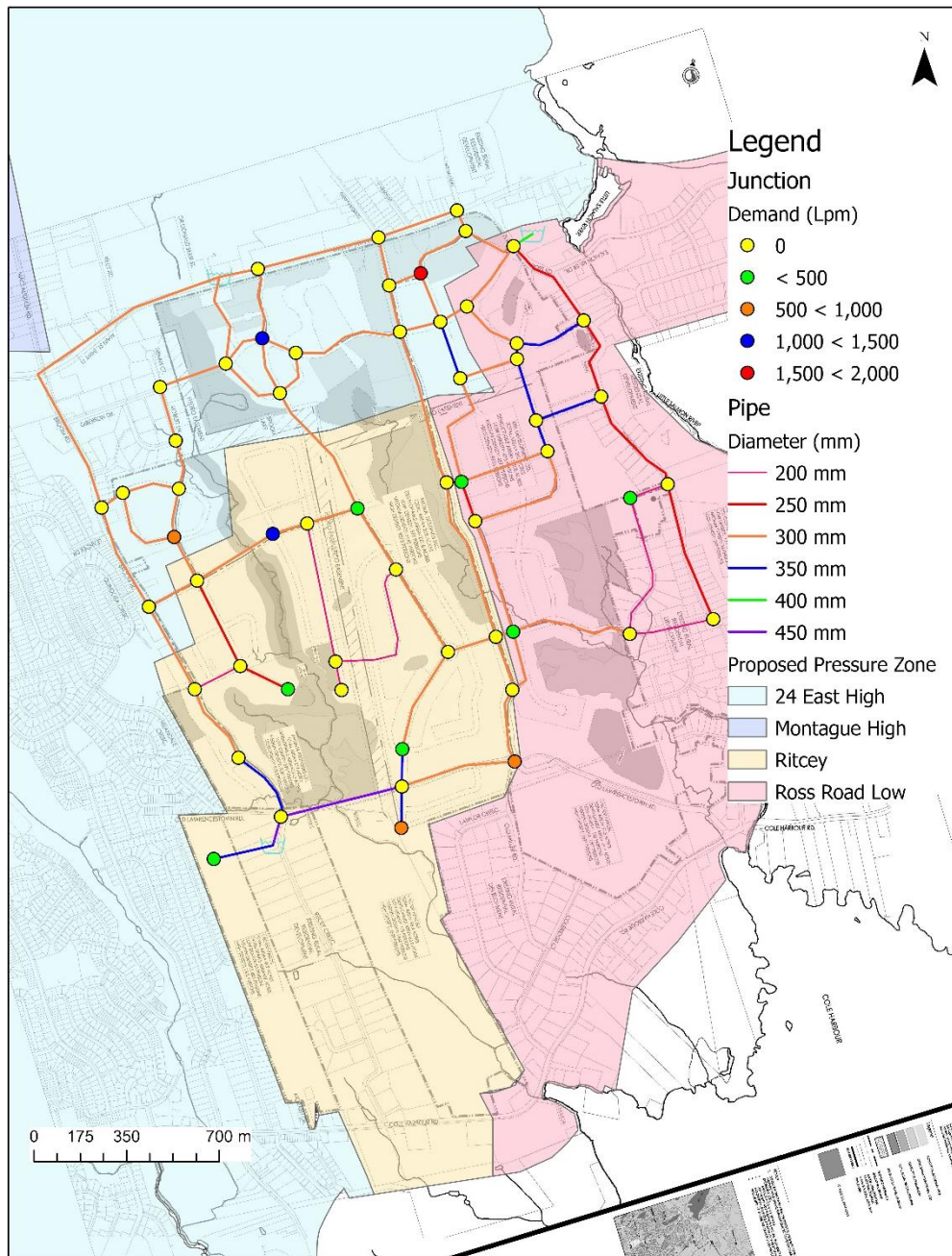


Figure 3-8: MHD Distribution (High-Density Scenario)



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan 3 Proposed Development

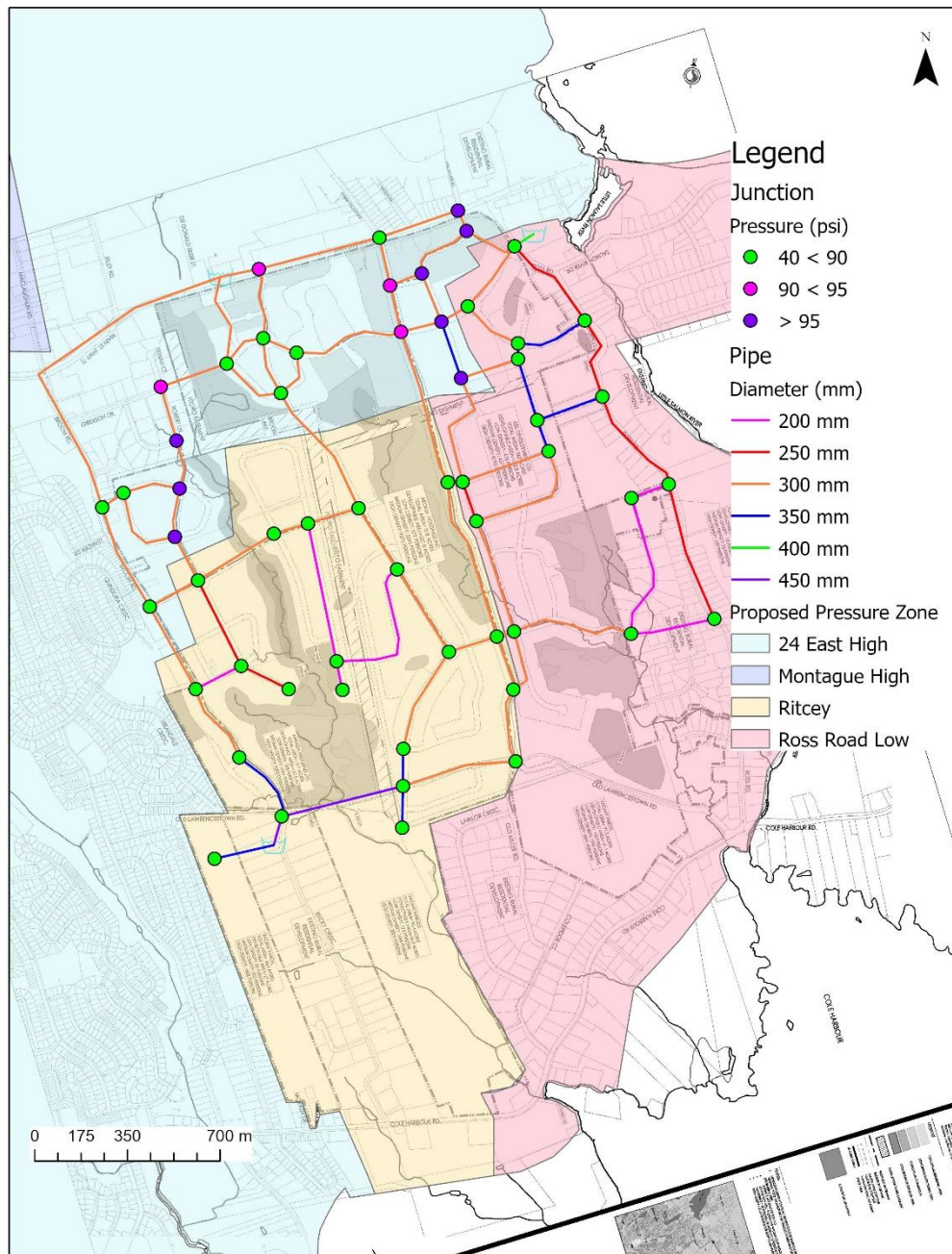


Figure 3-9: Pressure Distribution Under MHD (High-Density Scenario)



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan 3 Proposed Development

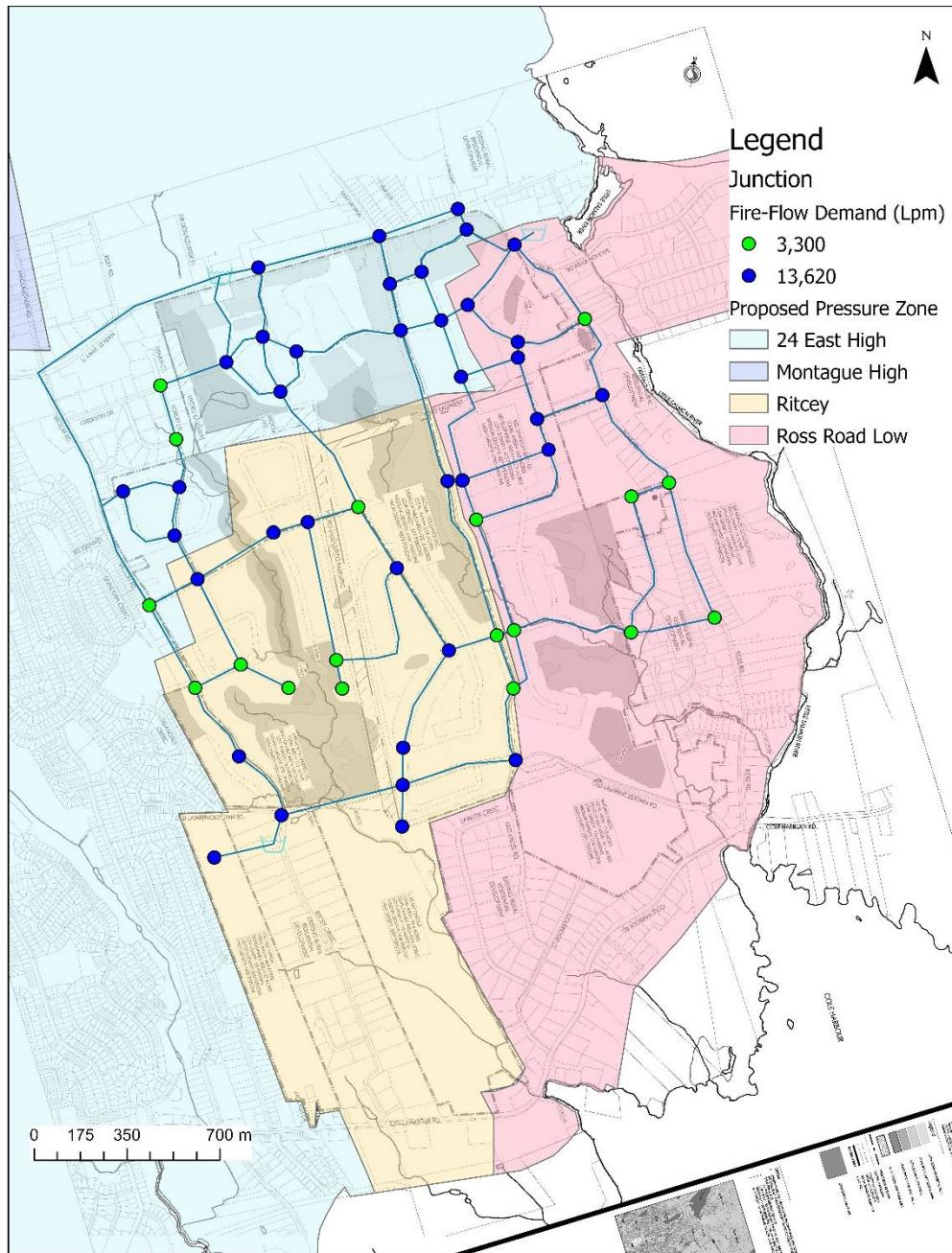


Figure 3-10: Required Fire Flow (High-Density Scenario)



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan 3 Proposed Development

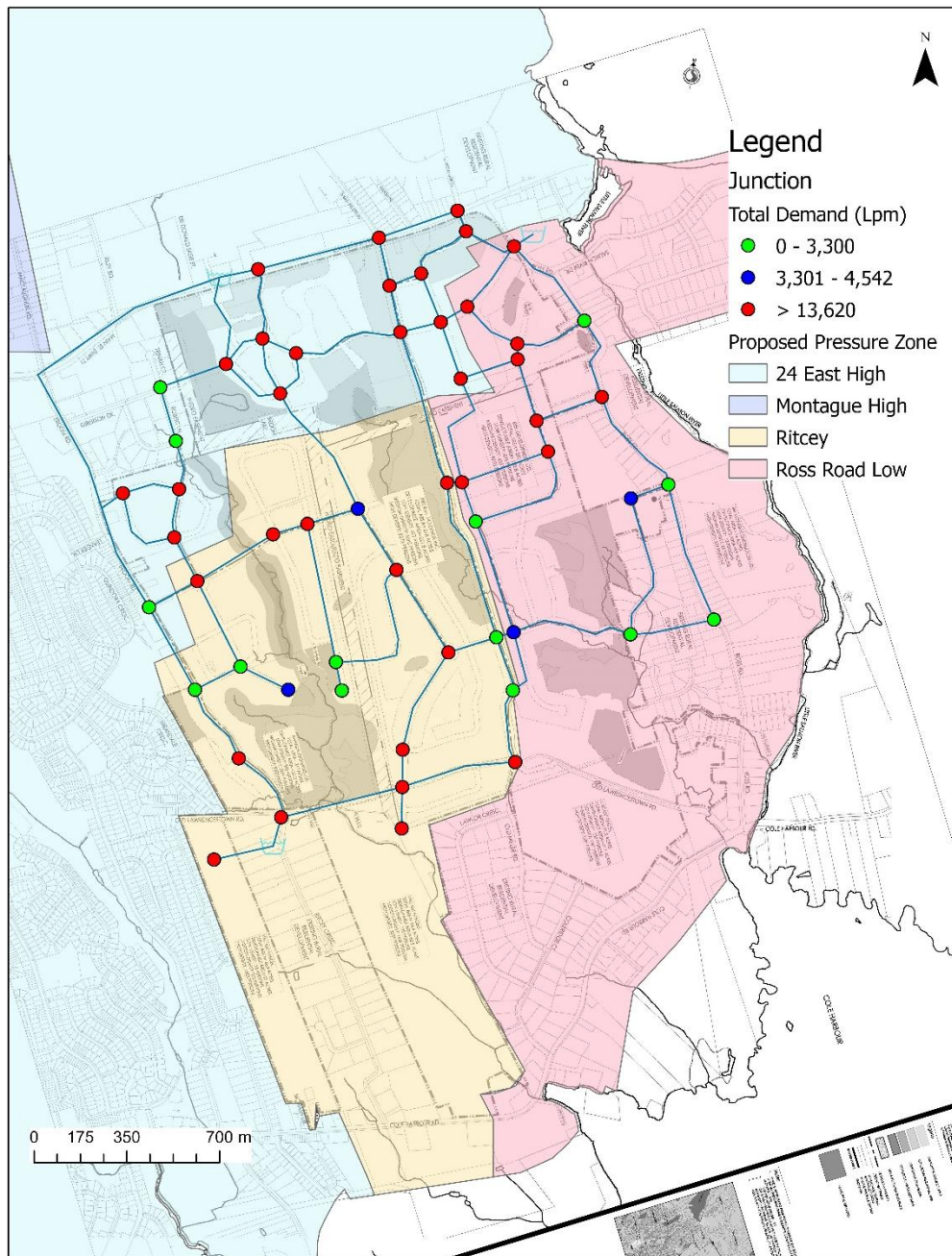


Figure 3-11: Total MDD + FF Demands (High-Density Scenario)



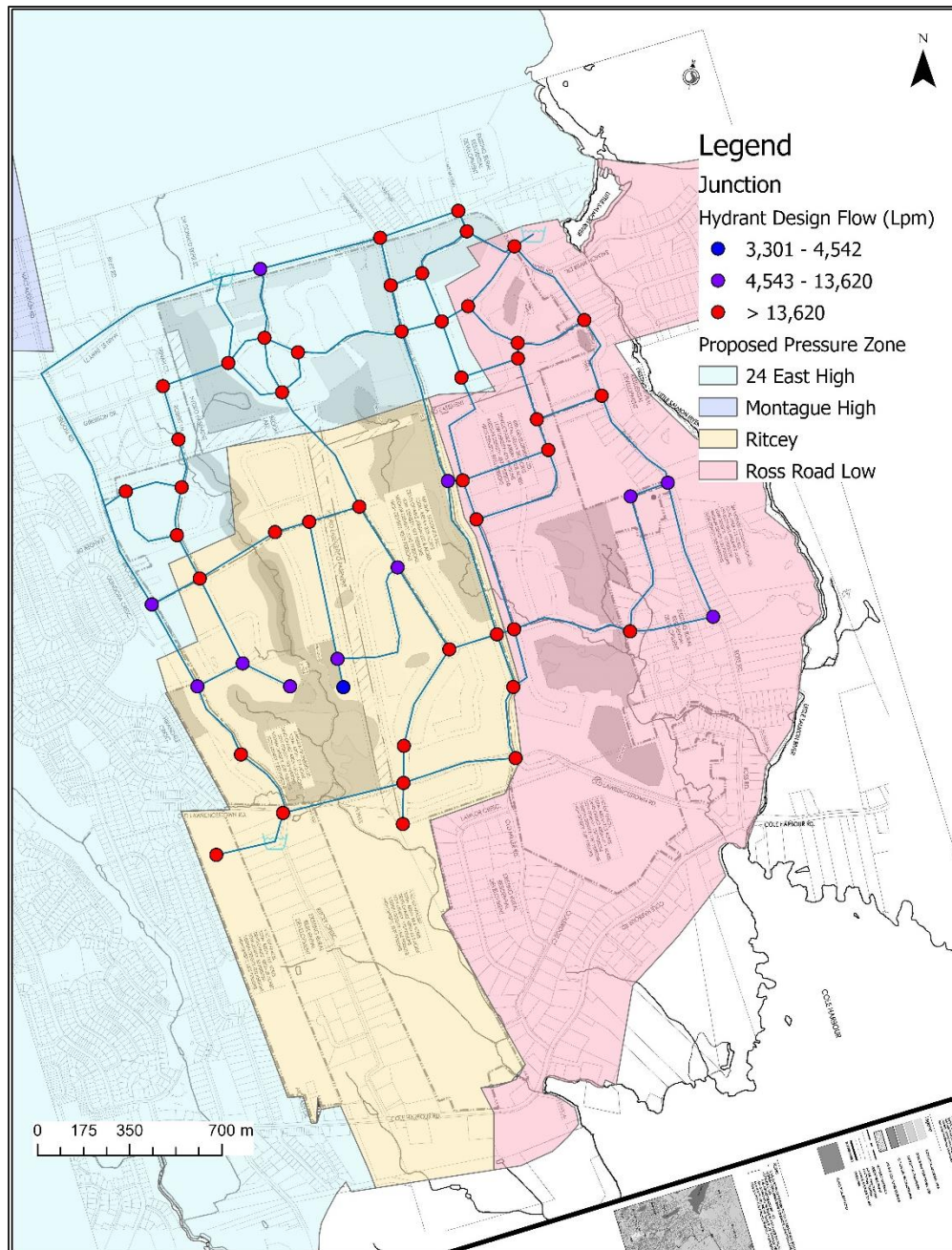


Figure 3-12: Available Hydrant Flow (High-Density Scenario)

3.3.4.2 Low-Density Population Scenario

Figure 3-13 illustrates the distribution of MDD for the low-density scenario throughout the model. As with the high-density scenario, the demands were distributed as described in Section 3.3.4.1. Figure 3-14 presents the anticipated corresponding pressures at each node, which range from 49 psi to 110 psi.



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan

3 Proposed Development

The distribution of PHD for the low-density scenario are presented in **Figure 3-15** and the resulting pressures are shown in **Figure 3-16**. Pressures under the PHD scenario range from approximately 49 psi to 110 psi. For this scenario, all pipe velocities are less than 1.5 m/s (in accordance with Halifax Water's Design Specifications).

MHD were also simulated, the distribution of MHDs and the resulting pressures are presented in **Figure 3-17** and **Figure 3-18**, respectively. Pressures under the MHD scenario range from approximately 49 psi to 110 psi.

As shown for the MHD, MDD and PHD, some locations have pressures greater than that specified in the Design Specification. In these instances, pressure reducing valves installed on the water service lines (in accordance with Halifax Water's Supplementary Standard Specifications) should be considered. Alternatively, a new pressure zone between Highway 7 and the re-delineated Ritcey pressure zone, fed by a PRV from 24 East High zone, could be considered.

For the low-density population scenario, only single residential homes were considered. Therefore, the required fire flow is 3,300 Lpm throughout the entire development. The total MDD + FF demand at each node is presented in **Figure 3-19**, and the results of the fire analysis are presented in **Figure 3-20**. The available fire flow range is approximately 4,500 Lpm to 30,000 Lpm. Since these fire flows greatly exceed the required fire flow for low-density single-family homes (3,300 Lpm), if this development scenario is selected the watermain sizing should be revisited. The large diameter pipes shown in the figures are required to achieve fire flow requirements for multi-unit residential developments (as is the case for the high-density scenario).

Also, as stated previously, without a full system model, it is unknown if the system can provide the fire flows presented. Therefore, it is recommended to examine the development's effect on the entire system by using a full (calibrated) system model. Hence the pressures and available fire flows presented in the report should be considered preliminary.



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan 3 Proposed Development

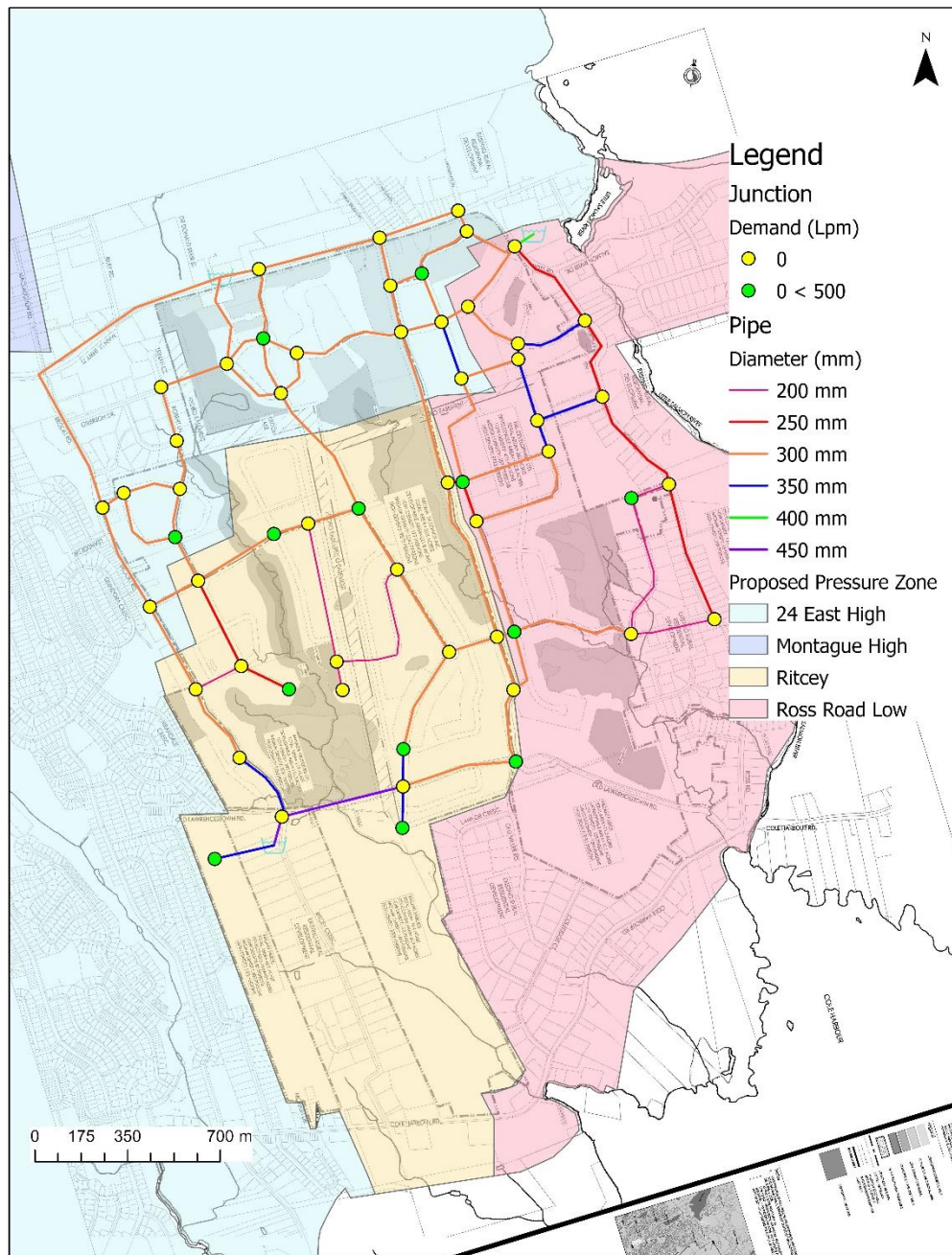


Figure 3-13: MDD Distribution (Low-Density Scenario)



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan 3 Proposed Development

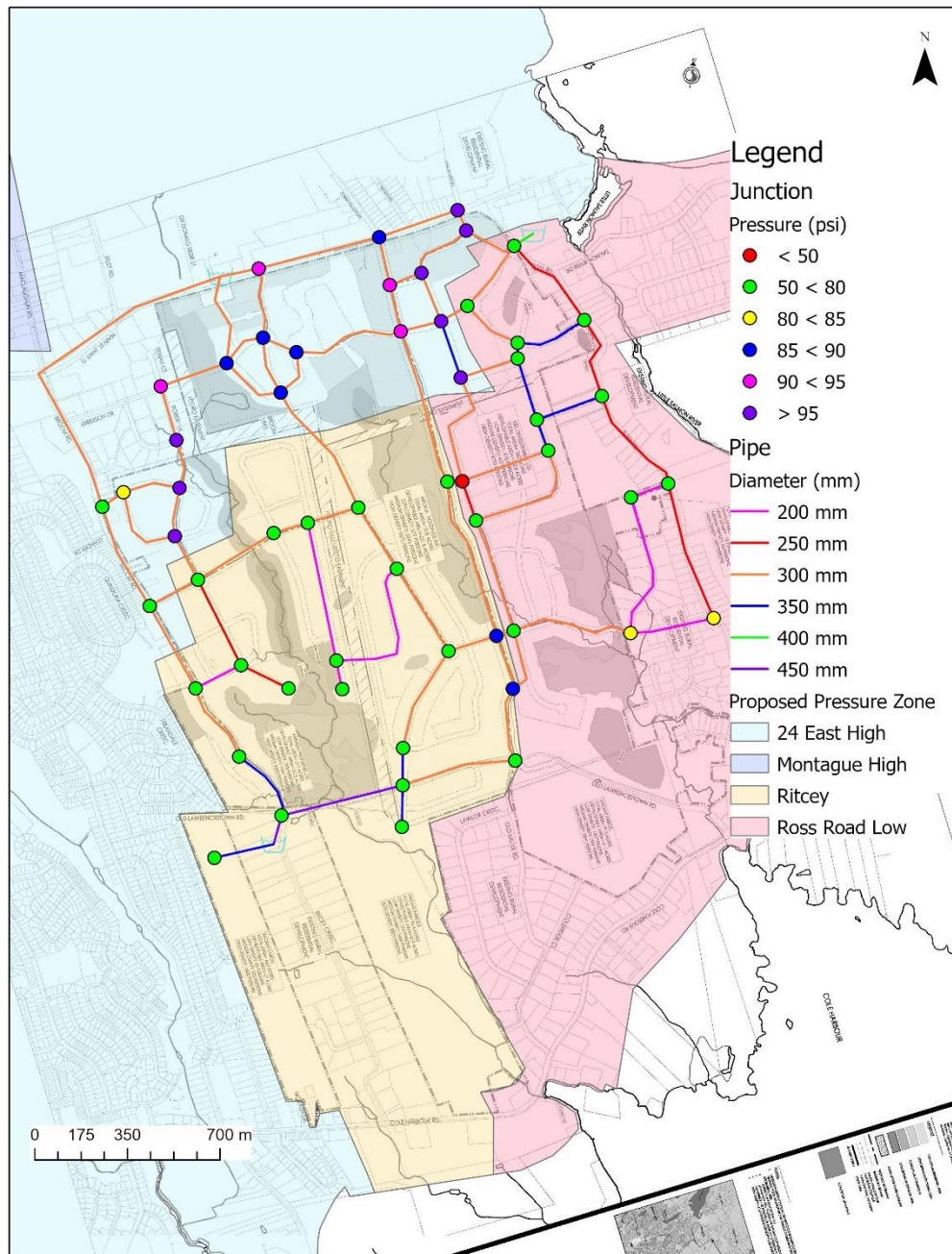


Figure 3-14: Pressure Distribution Under MDD (Low-Density Scenario)



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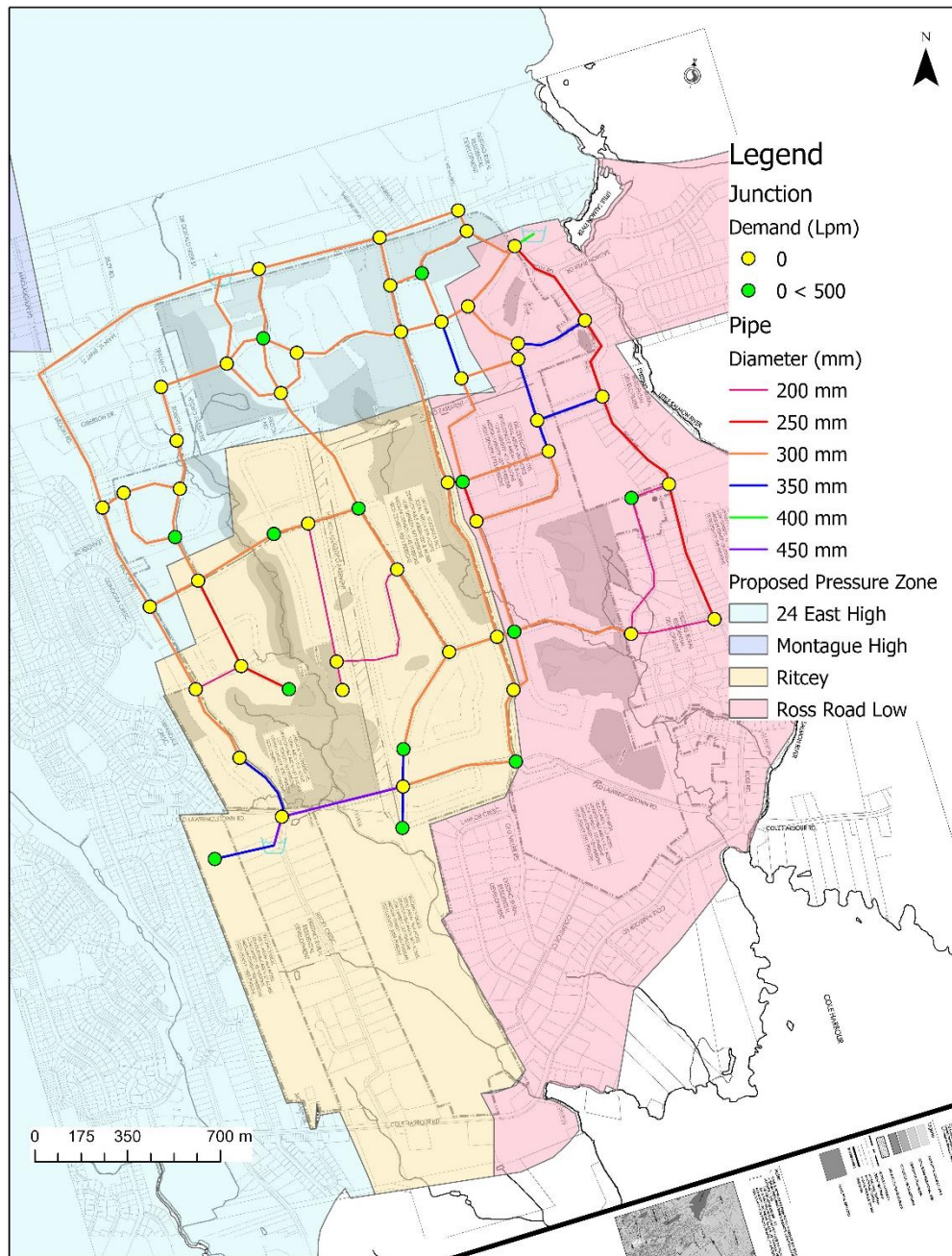


Figure 3-15: PHD Distribution (Low-Density Scenario)



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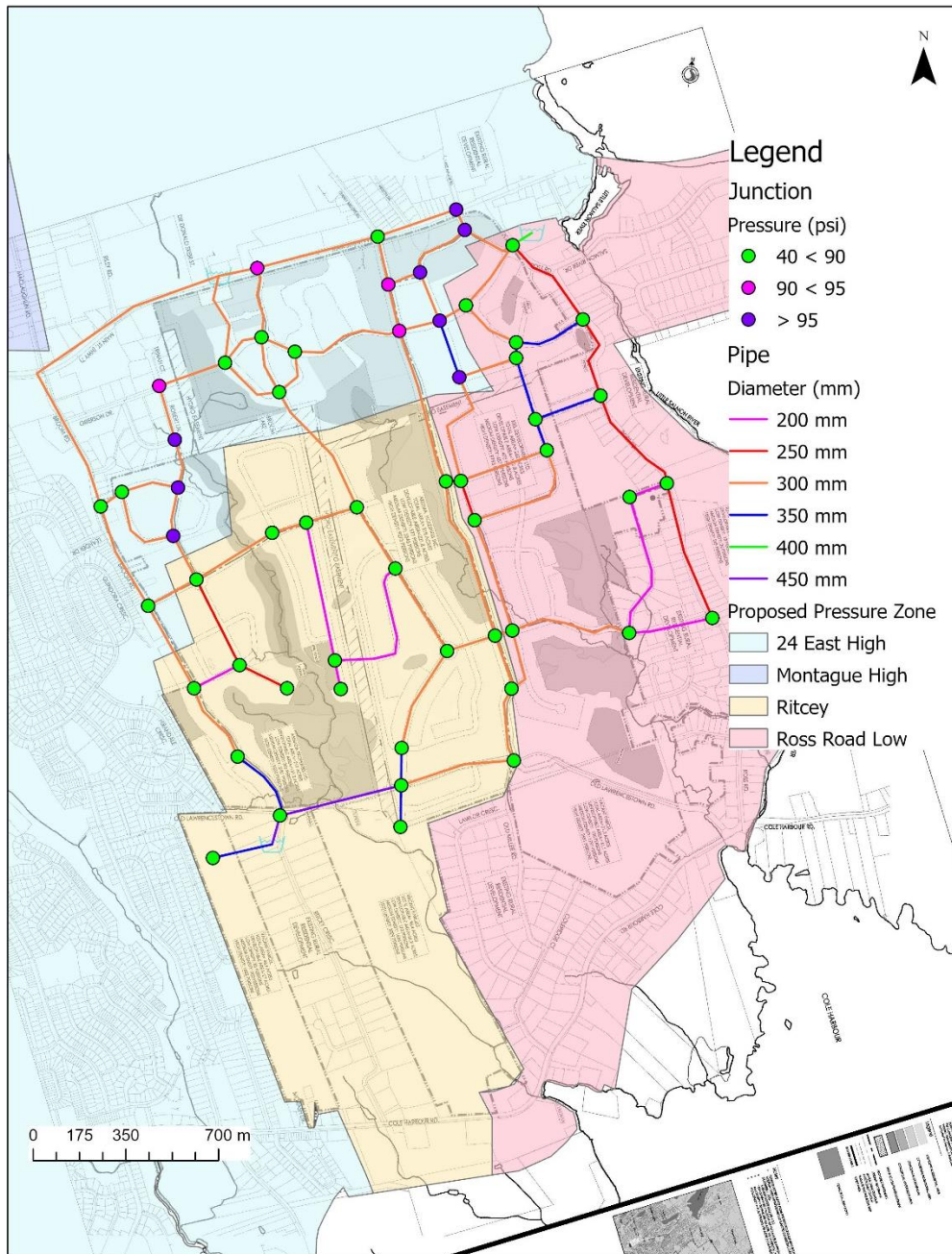


Figure 3-16: Pressure Distribution Under PHD (Low-Density Scenario)



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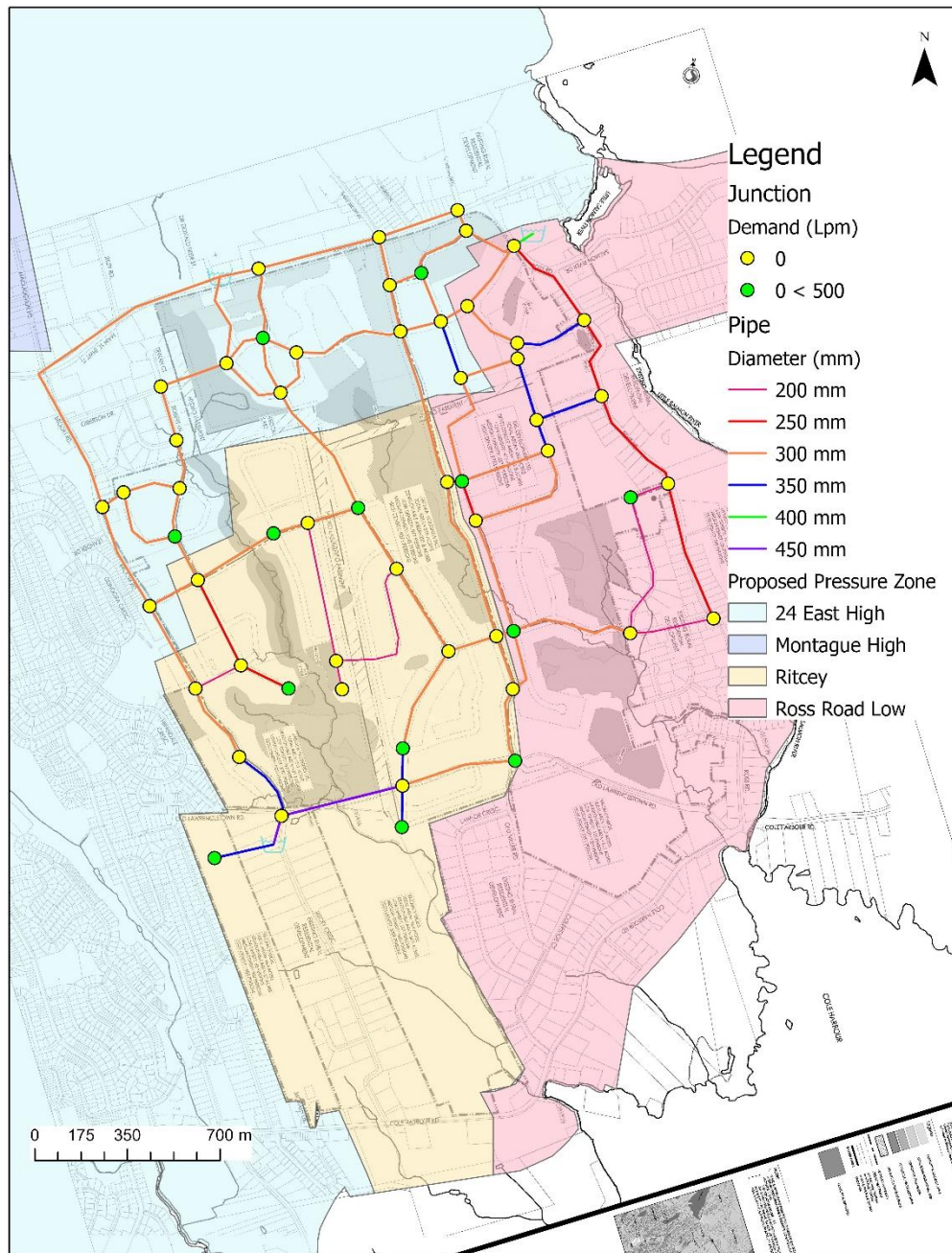


Figure 3-17: MHD Distribution (Low-Density Scenario)



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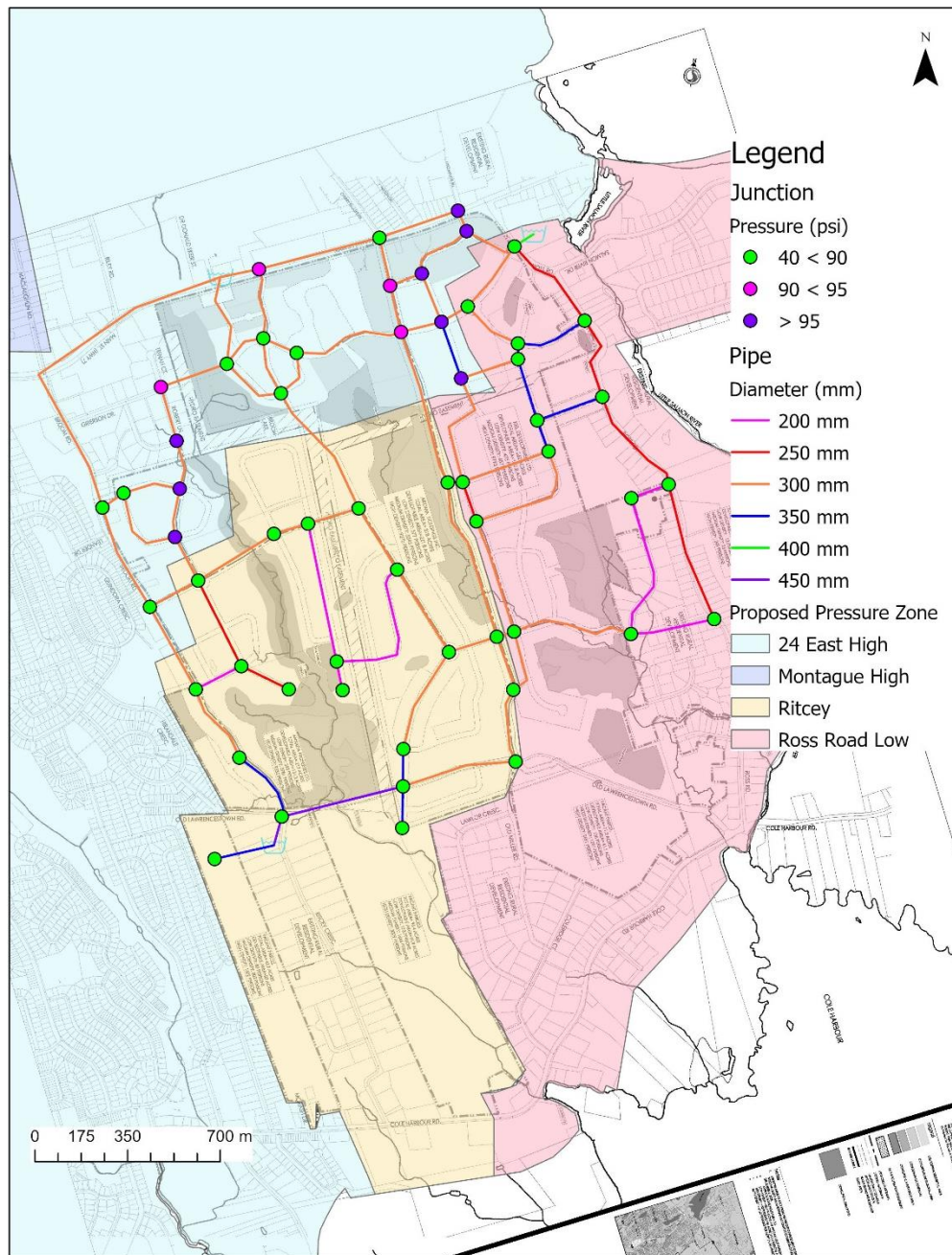


Figure 3-18: Pressure Distribution Under MHD (Low-Density Scenario)



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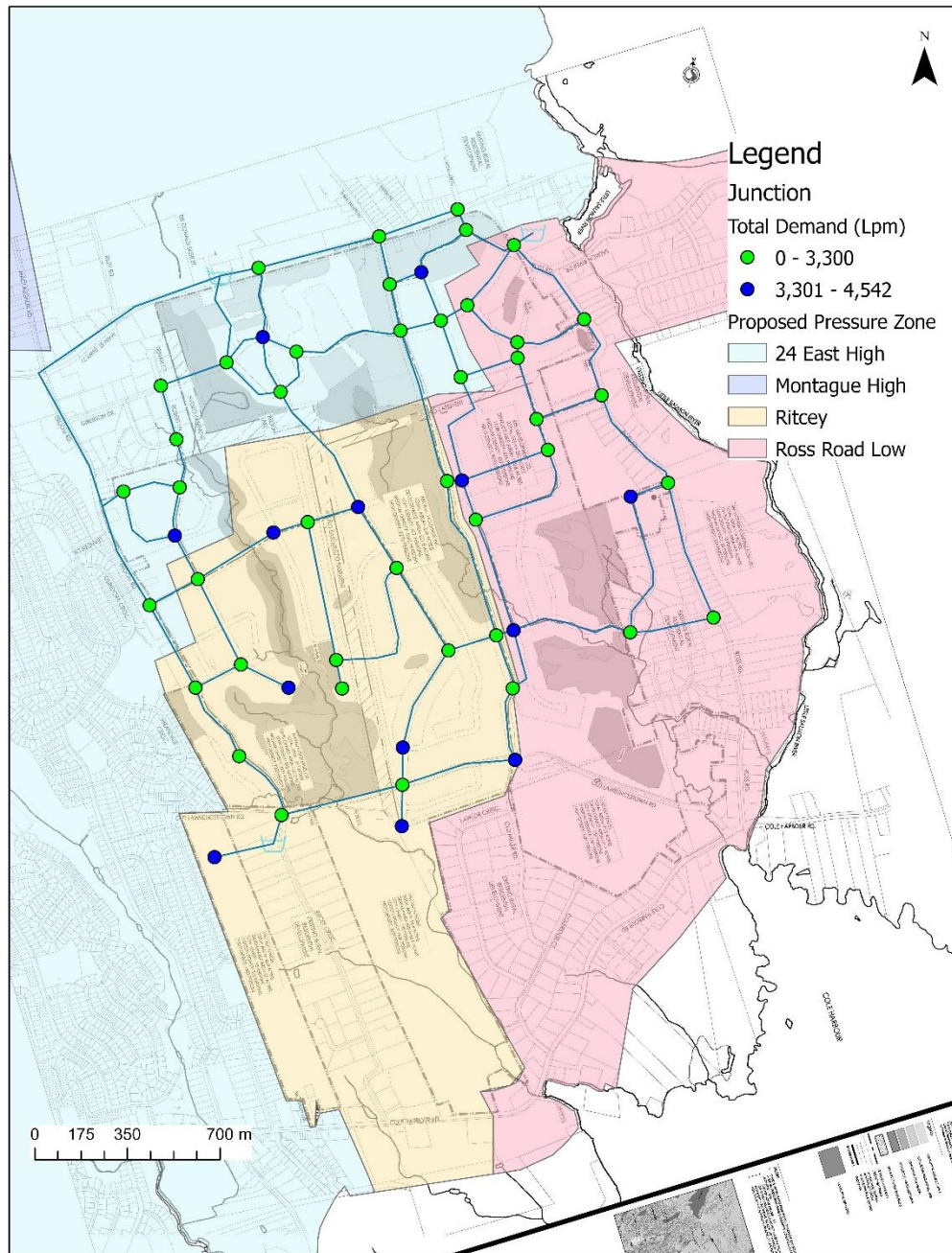


Figure 3-19: Total MDD + FF Demands (Low-Density Scenario)



Halifax Regional Municipality Future Serviced Communities – Westphal Water Servicing Plan 3 Proposed Development

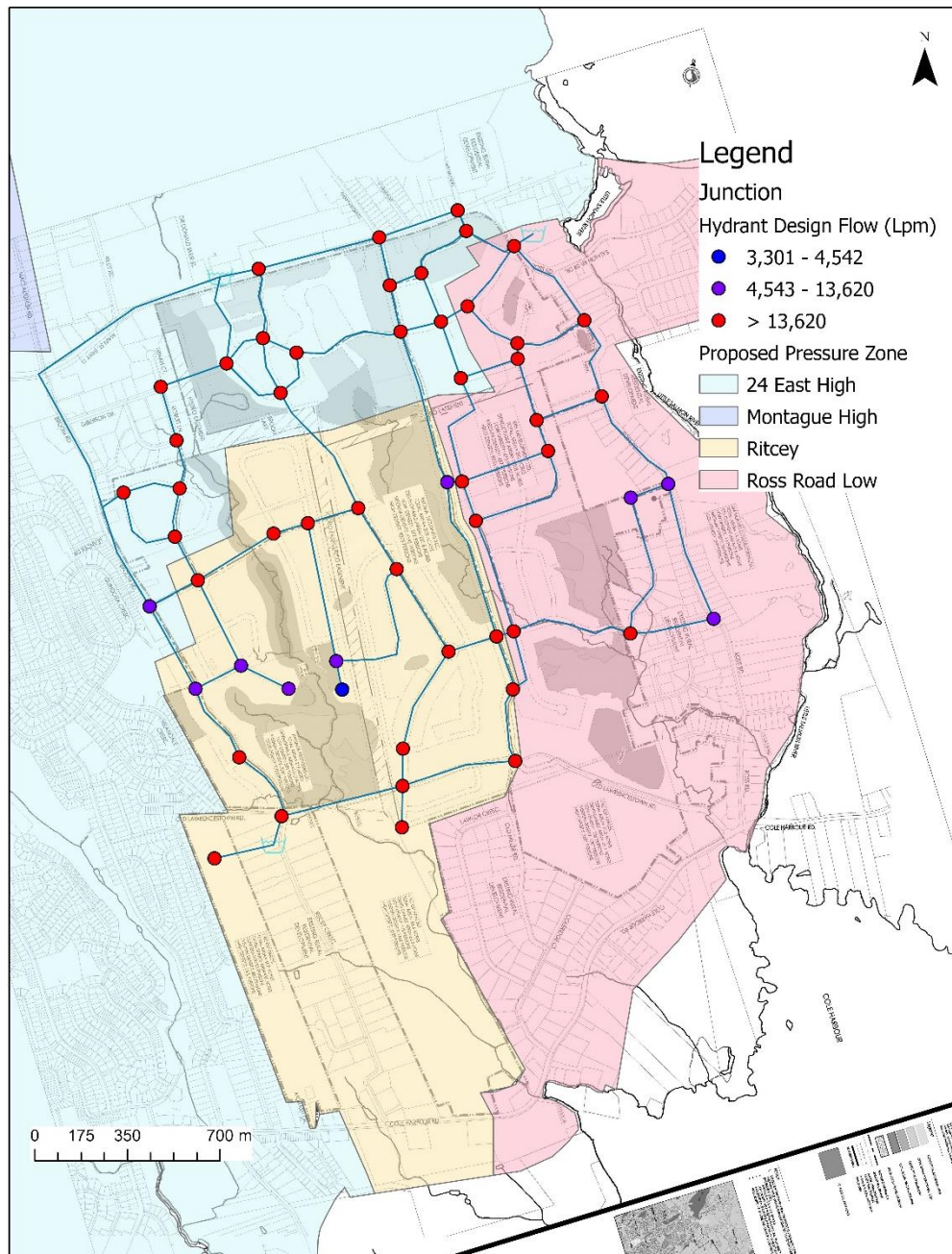


Figure 3-20: Available Hydrant Flow (Low-Density Scenario)



4 Conclusions and Recommendations

4.1 Conclusions

The Westphal development is proposed between Broom Road on the west, and Ross Road to the east in southeastern area of HRM. A range of development scenarios were assessed to estimate high- and low-density population projections. These scenarios were used to estimate ADD, MHD, MDD, and PHD for the development. The demands were then used to assess the requirements for servicing the development with potable water from Halifax Water's existing water system network.

Level of service and design criteria from Halifax Water's Design Specifications (2023) were used to assess the proposed servicing scheme.

A review of the adjacent pressure zones, proposed system improvements, and proposed site grading suggests the development can be serviced with potable water from the existing Ross Road Low, Ritcey Low, and 24 East High pressure zones. A water system model was developed using InfoWater Pro to estimate the development distribution system requirements to achieve the level of service set out in Halifax Water's Design Specification. The model development assumes that the connection to each existing pressure zone is a constant HGL with unlimited flow (i.e. the connections are modelled as fixed head reservoirs). This assumption does not reflect the actual system, however, in the absence of a full system model it is a reasonable assumption.

The proposed watermain sizes range from 200 mm to 450 mm diameter, with the majority being 300 mm diameter.

The water model results indicate the following:

Table 4-1: Summary of Water Model Results

Flow Scenario	Pressure Range (psi)	Max Velocity (m/s)	Available Fire Flow (Lpm)
MDD High Density	49 – 110	< 1.5	N/A
PHD High Density	48 – 108	< 1.5	N/A
MHD High Density	49 – 110	< 1.5	N/A
MDD + FF High Density	> 22	< 2.4	4,500 - 28,500*
MDD Low Density	49 – 110	< 1.5	N/A
PHD Low Density	49 – 110	< 1.5	N/A
MHD Low Density	49 – 110	< 1.5	N/A
MDD + FF Low Density	> 22	< 2.4	4,500 - 30,000*



* Based on the assumptions of a constant HGL at the connections to the existing pressure zones. Therefore, the values for available fire flow should be considered with a low level of confidence.

Since the maximum pressures for each scenario exceed the range presented in Halifax Water's Design Specification, pressure reducing valves installed on the water service lines (in accordance with Halifax Water's Supplementary Standard Specifications) should be considered in those locations. Alternatively, a new pressure zone, south of Highway 7, may also be considered during the next design phase. It is assumed the new pressure zone would be controlled by a pressure reducing valve from the 24 East High pressure zone.

4.2 Recommendations

The presented subdivision plan is preliminary and subject to change, therefore the MHD, MDD, PHD and required FF demands presented in this report may change resulting in changes to proposed water distribution preliminary design. It is recommended that the level of service and distribution system requirements be reassessed during subsequent design stages. Also, during the next stages of design the sizing and placement of regional water infrastructure should be considered.

In the absence of a full system model the effect of the proposed development on the level of service of the remaining system could not be assessed. Also, the effect of potential restrictions within the existing system on the proposed development could not be assessed. In Halifax Water's 2019 IMP, it was recommended that an all-pipe hydraulic model be developed. An all-pipe model can be used to assess fire flow objectives at each property or node in the system. It is recommended that the proposed development be incorporated in the all-pipe model to perform a more refined fire flow level of service assessment for the development.

The scope of the water and wastewater servicing analysis included in the Future Serviced Communities Study does not include wastewater treatment facilities or water treatment plants. Halifax Water has a well-established strategy for water and wastewater infrastructure planning as it relates to asset renewal, compliance, and growth. The Integrated Resource Plan (IRP) shapes Halifax Water's capital program by identifying resource and finance needs. There are three major plans contained within the IRP, those being the Asset Management Plan, Compliance Plan, and Infrastructure Master Plan (IMP). The IRP aims to provide regional water and wastewater infrastructure needed to support planned growth.

The IMP is a comprehensive infrastructure master plan for both water and wastewater that supports growth. As part of the IRP approach, the plan is updated at regular intervals to ensure the consolidated long-term program remains current. Halifax Regional Municipality supplies Halifax Water with growth projections to be considered within the IRP, in this case, the Future Serviced Communities Studies: Sandy Lake, Highway 102 Corridor, Morris Lake Expansion, and Westphal will be incorporated into the upcoming review of the latest iteration of the IRP. Growth projections are used as input to analysis, such as water and wastewater models, which aid in determining preferred servicing strategies.



Appendix A Hydrant Flow Test





Water Flow Test Summary

Broom Road
Stantec

Type of Test: Flow Test Test # : 1
Location: See Below Tested By: Matt Eisan
Municipality: HRM Date: August 8, 2024

*SYSTEM DATA

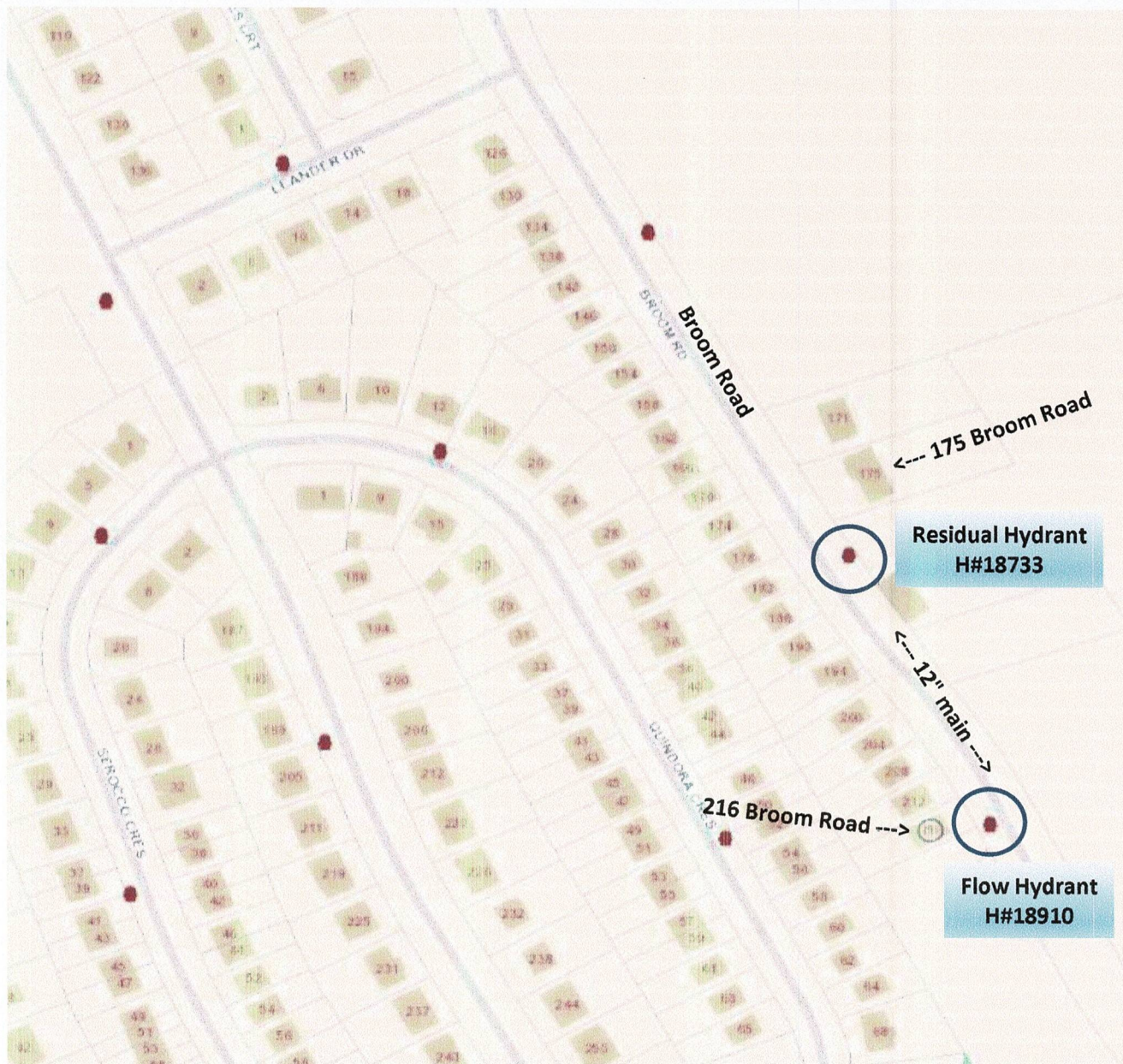
Size of Main: 12" Dead Ends: X Grid: Loop:
Source Reliable: Yes (CITY) If No - Explain
Comments: All flows are in USGPM

*TEST DATA

Location of Hydrants: Residual: Hydrant # H18733 - beside Civic # 175 Broom Road
Flow: Hydrant # H18910 - in front of Civic # 216 Broom Road

Normal Pressure: 79 psi Time: 9:00 PM

Test #	# of Outlets	Oriface Size	Pitot Reading (PSIG)	Equivelent Flow (GPM)	Total Flow (GPM)	Residual Pressure (PSIG)	Comments
0	0					79	Used 2 1/2" Hose Monster
1	1	2 1/2"	28	893	893	70	
2	2	2 1/2"	23	809	1582	62	
		2 1/2"	21	773			





Water Flow Test Summary

Highway # 7 at Westphal Way
Stantec

Type of Test: Flow Test Test # : 1
Location: See Below Tested By: Matt Eisan
Municipality: HRM Date: August 8, 2024

*SYSTEM DATA

Size of Main: 12" Dead Ends: Grid: Loop: X
Source Reliable: Yes (CITY) If No - Explain
Comments: All flows are in USGPM

*TEST DATA

Location of Hydrants: Residual: Hydrant # H18956 - corner of Hwy #7 and Westphal Way
Flow: Hydrant # H18957 - in front of Civic # 1031 Hwy #7

Normal Pressure: 92 psi Time: 9:37 PM

Test #	# of Outlets	Oriface Size	Pitot Reading (PSIG)	Equivalent Flow (GPM)	Total Flow (GPM)	Residual Pressure (PSIG)	Comments
0	0					92	Used 2 1/2" Hose Monster
1	1	2 1/2"	32	954	954	88	
2	2	2 1/2"	23	809	1669	72	
		2 1/2"	26	860			





Water Flow Test Summary

Ritcey Crescent
Stantec

Type of Test: Flow Test Test # : 1
Location: See Below Tested By: Matt Eisan
Municipality: HRM Date: August 8, 2024

*SYSTEM DATA

Size of Main: 12" Dead Ends: X Grid: _____ Loop: _____
Source Reliable: Yes (CITY) If No - Explain _____
Comments: All flows are in USGPM

*TEST DATA

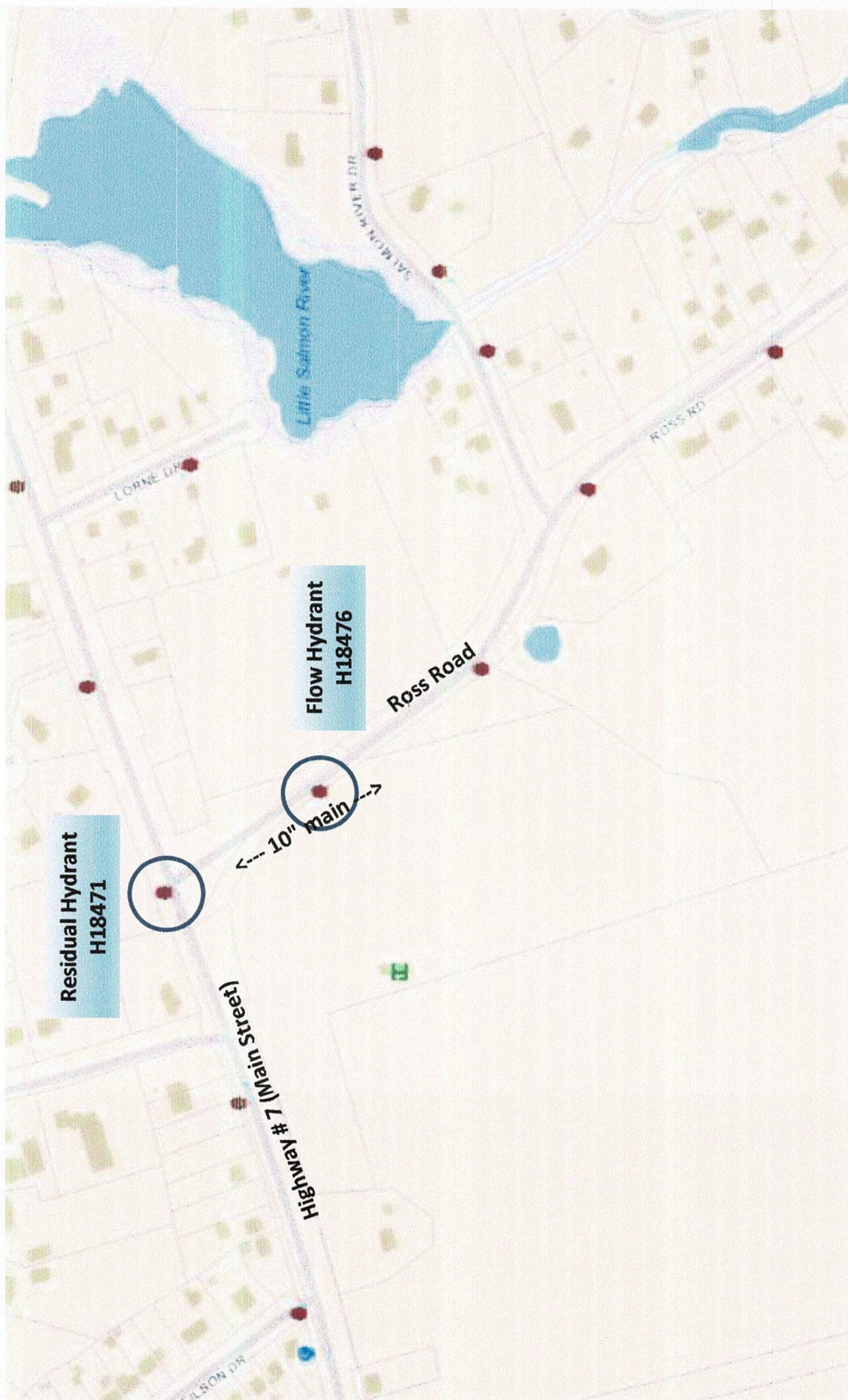
Location of Hydrants: Residual: Hydrant # H18704 - at Civic # 250 Ritcey Crescent
Flow: Hydrant # H18705 - by Civic # 280 Ritcey Crescent

Normal Pressure: 70 psi Time: 11:00 PM

Test #	# of Outlets	Oriface Size	Pitot Reading (PSIG)	Equivelent Flow (GPM)	Total Flow (GPM)	Residual Pressure (PSIG)	Comments
0	0					70	Used 2 1/2" Hose Monster
1	1	2 1/2"	22	791	791	59	
2	2	2 1/2"	17	695	1430	50	
		2 1/2"	19	735			

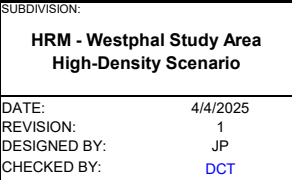


Test #	# of Outlets	Oriface Size	Pitot Reading (PSIG)	Equivalent Flow (GPM)	Total Flow (GPM)	Residual Pressure (PSIG)	Comments
0	0					111	Used 2 1/2" Hose Monster
1	1	2 1/2"	40	1067	1067	102	
2	2	2 1/2"	24	826	1702	80	
		2 1/2"	27	876			



Appendix B Sanitary Sewer Peak Flow Estimates





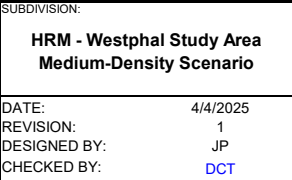
(Halifax)

FILE NUMBER: 160410459

MAX PEAK FACTOR (RES.)=	4.0	AVG. DAILY FLOW / PERSON	375	l/p/day	MINIMUM VELOCITY	0.60	m/s
MIN PEAK FACTOR (RES.)=	2.0	COMMERCIAL	60,000	lha/day	MAXIMUM VELOCITY	4.50	m/s
PEAKING FACTOR (INDUSTRIAL):	2.4	INDUSTRIAL (HEAVY)	55,000	lha/day	MANNINGS n	0.013	
PEAKING FACTOR (ICI >20%):	1.5	INDUSTRIAL (LIGHT)	35,000	lha/day	BEDDING CLASS	B	
PERSONS / SINGLE	3.35	INSTITUTIONAL	60,000	lha/day	MINIMUM COVER	1.60	m
PERSONS / TOWNHOME	3.35	INFILTRATION	0.28	l/s/Ha	HARMON CORRECTION FACTOR	1.00	
PERSONS / MULTI-UNIT	2.25						

LOCATION			RESIDENTIAL AREA AND POPULATION								COMMERCIAL		INDUSTRIAL (L)		INDUSTRIAL (H)		INSTITUTIONAL		GREEN / UNUSED		C+H	INFILTRATION			TOTAL	PIPE										
AREA ID NUMBER	FROM M.H.	TO M.H.	AREA (ha)	SINGLE	UNITS TOWN	MULTI	POP.	CUMULATIVE AREA (ha)	POP.	PEAK FACT.	PEAK FLOW (l/s)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	PEAK FLOW (l/s)	TOTAL AREA (ha)	ACCU. AREA (ha)	INFILT. FLOW (l/s)	FLOW (l/s)	LENGTH (m)	DIA (mm)	MATERIAL	CLASS	SLOPE (%)	CAP. (FULL) (l/s)	CAP. V PEAK FLOW (%)	VEL. (FULL) (m/s)	VEL. (ACT.) (m/s)			
R40A R37A R33B R32A	40	39	34.59	0	0	0	4595	34.59	4595	3.28	65.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	34.59	34.59	9.7	75.1	355.0	250	PVC	SDR 35	2.00	85.7	87.55%	1.73	1.75			
	39	38	0.00	0	0	0	0	34.59	4595	3.28	65.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	34.59	9.7	75.1	119.5	375	PVC	SDR 35	0.50	114.8	65.41%	1.09	1.01			
	38	37	0.00	0	0	0	0	34.59	4595	3.28	65.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	34.59	9.7	75.1	101.3	375	PVC	SDR 35	0.50	114.8	65.41%	1.09	1.01			
	37	36	11.83	0	0	0	1571	46.41	6166	3.16	84.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	11.83	46.41	13.0	97.5	129.1	375	PVC	SDR 35	0.50	114.8	84.99%	1.09	1.09			
	36	35	0.00	0	0	0	0	46.41	6166	3.16	84.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	46.41	13.0	97.5	137.8	375	PVC	SDR 35	0.50	114.8	84.99%	1.09	1.09			
	35	34	0.00	0	0	0	0	46.41	6166	3.16	84.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	46.41	13.0	97.5	148.3	375	PVC	SDR 35	0.50	114.8	84.99%	1.09	1.09			
	34	33	0.00	0	0	0	0	46.41	6166	3.16	84.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	46.41	13.0	97.5	114.5	375	PVC	SDR 35	0.50	114.8	84.99%	1.09	1.09			
	33	32	19.46	0	0	0	1602	65.87	7768	3.06	103.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	19.46	65.87	18.4	121.7	107.8	375	PVC	SDR 35	0.80	145.2	83.83%	1.38	1.38			
	32	31	40.43	0	0	0	3330	106.30	11098	2.91	140.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	40.43	106.30	29.8	169.9	226.2	375	PVC	SDR 35	1.50	198.8	85.47%	1.89	1.90			
	31	30	0.00	0	0	0	0	106.30	11098	2.91	140.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	106.30	29.8	169.9	238.1	375	PVC	SDR 35	1.50	198.8	85.47%	1.89	1.90			
30	29	0.00	0	0	0	0	106.30	11098	2.91	140.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	106.30	29.8	169.9	885.7	375	PVC	SDR 35	1.40	192.0	88.47%	1.82	1.85				
R9A, G9A, G9B	9	8	9.29	0	0	0	1216	9.29	1216	3.74	19.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	39.85	39.85	11.2	30.9	279.3	250	PVC	SDR 35	0.40	38.3	80.62%	0.77	0.76			
	8	7	0.00	0	0	0	0	9.29	1216	3.74	19.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	39.85	11.2	30.9	149.6	250	PVC	SDR 35	0.50	42.9	72.11%	0.86	0.82			
	7	6	0.00	0	0	0	0	9.29	1216	3.74	19.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	39.85	11.2	30.9	186.0	250	PVC	SDR 35	3.00	105.0	29.44%	2.11	1.54			
	6	5	5.96	0	0	0	795	15.25	2011	3.58	31.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	5.96	45.82	12.8	44.1	92.4	250	PVC	SDR 35	4.61	130.1	33.90%	2.62	1.99			
	5	4	0.00	0	0	0	0	15.25	2011	3.58	31.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	45.82	12.8	44.1	199.8	250	PVC	SDR 35	1.30	69.2	63.77%	1.39	1.28			
R20A, I20A, G20A, G20C, G20B, C20A	20	19	14.57	0	0	0	1907	14.57	1907	3.60	29.8	6.02	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.3	48.60	48.60	13.6	60.7	106.0	300	PVC	SDR 35	0.49	67.5	89.98%	0.96	0.98			
	19	18	0.00	0	0	0	0	14.57	1907	3.60	29.8	6.02	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.3	0.00	48.60	13.6	60.7	167.2	300	PVC	SDR 35	0.50	67.9	89.45%	0.96	0.98			
	18	17	0.00	0	0	0	0	14.57	1907	3.60	29.8	0.00	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.3	0.00	48.60	13.6	60.7	151.8	300	PVC	SDR 35	0.50	67.9	89.45%	0.96	0.98			
	17	16	2.31	0	0	0	308	16.88	2215	3.55	34.1	0.00	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.3	2.31	50.91	14.3	65.7	204.0	300	PVC	SDR 35	1.40	113.6	57.83%	1.61	1.44			
	16	15	4.18	0	0	0	558	21.06	2773	3.47	41.8	0.00	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.3	4.18	55.10	15.4	74.5	404.2	300	PVC	SDR 35	2.85	162.2	45.94%	2.30	1.91			
	15	14	0.00	0	0	0	0	21.06	2773	3.47	41.8	0.00	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.3	0.00	55.10	15.4	74.5	127.1	300	PVC	SDR 35	3.00	166.3	44.81%	2.36	1.96			
	14	13	0.00	0	0	0	0	21.06	2773	3.47	41.8	0.00	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.3	0.00	55.10	15.4	74.5	126.3	300	PVC	SDR 35	1.80	128.8	57.85%	1.83	1.64			
	13	4	0.00	0	0	0	0	21.06	2773	3.47	41.8	0.00	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.3	0.00	55.10	15.4	74.5	343.2	300	PVC	SDR 35	0.80	85.9	86.77%	1.22	1.23			
	R12A G11A, R11A	12	11	23.08	0	0	0	3066	23.08	3066	3.43	45.7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	23.08	23.08	6.5	52.2	331.6	300	PVC	SDR 35	0.40	60.7	85.90%	0.86	0.87		
11		10	46.98	0	0	0	6150	70.06	9216	2.99	119.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	48.53	71.61	20.1	139.6	641.0	375	PVC	SDR 35	1.10	170.2	82.03%	1.61	1.60			
10		4	0.00	0	0	0	0	70.06	9216	2.99	119.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	71.61	20.1	139.6	196.7	375	PVC	SDR 35	3.96	323.0	43.23%	3.06	2.52			
G4A	4	3A	0.00	0	0	0	0	106.37	14000	2.81	170.6	0.00	6.02	0.00	0.00	0.00	0.00	10.60	10.60	11.5	19.06	68.59	53.6	235.8	64.1	375	PVC	SDR 35	2.90	276.4	85.32%	2.62	2.64			
R26A, C26A	26	25	25.31	0	0	0	3378	25.31	3378	3.40	49.8	7.46	7.46	0.00	0.00	0.00	0.00	0.00	0.00	7.8	32.77	32.77	9.2	66.8	229.7	250	PVC	SDR 35	1.50	74.2	89.95%	1.49	1.53			
	25	24	0.00	0	0	0	0	25.31	3378	3.40	49.8	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	7.8	0.00	32.77	9.2	66.8	117.7	375	PVC	SDR 35	0.40	102.7	65.04%	0.97	0.90			
R24A	24	23	35.62	0	0	0	4754	60.93	8132	3.04	107.4	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	5.2	35.62	68.39	19.2	131.7	119.2	375	PVC	SDR 35	1.00	162.3	81.17%	1.54	1.53			
	23	22	0.00	0	0	0	0	60.93	8132	3.04	107.4	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	5.2	0.00	68.39	19.2	131.7	217.4	375	PVC	SDR 35	1.00	162.3	81.17%	1.54	1.53			
	22	21	0.00	0	0	0	0	60.93	8132	3.04	107.4	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	5.2	0.00	68.39	19.2	131.7	286.4	375	PVC	SDR 35	2.32	247.2	53.29%	2.34	2.04			
	21	3A	0.00	0	0	0	0	60.93	8132	3.04	107.4	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	5.2	0.00	68.39	19.2	131.7	309.3	375	PVC	SDR 35	1.50	198.7	66.29%	1.88	1.75			
G2B, G2A	3A	3	0.00	0	0	0	0	167.31	22132	2.61	250.6	0.00	13.48	0.00	0.00	0.00	0.00	10.60	10.60	16.7	0.00	259.98	72.8	340.1	156.8	450	PVC	SDR 35	1.80	403.3	84.32%	2.46	2.46			
	3	2	0.00	0	0	0	0	167.31	22132	2.61	250.6	0.00	13.48	0.00	0.00	0.00	0.00	10.60	10.60	16.7	0.00	259.98	72.8	340.1	104.3	450	PVC	SDR 35	1.80	403.3	84.32%	2.46	2.46			
	2	1	0.00	0	0	0	13	167.31	22145	2.61	250.7	0.00	13.48	0.00	0.00	0.00	0.00	10.60	10.60	16.7	29.06	289.04	80.9	348.3	121.2	450	PVC	SDR 35	1.80	403.3	86.37%	2.46	2.47			
R28A	28	27	31.47	0	0	0	2591	31.47	2591	3.50	39.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	31.47	31.47	8.8	48.1	569.2	250	PVC	SDR 35	3.75	117.4	40.98%	2.36	1.90			

	SUBDIVISION:		SANITARY SEWER DESIGN SHEET (Halifax) FILE NUMBER: 160410459										DESIGN PARAMETERS																								
	HRM - Westphal Study Area Low-Density Scenario												MAX PEAK FACTOR (RES.)= 4.0					AVG. DAILY FLOW / PERSON 375 l/p/day					MINIMUM VELOCITY 0.60 m/s														
	DATE: 4/4/2025 REVISION: 1 DESIGNED BY: JP CHECKED BY: DCT												MIN PEAK FACTOR (RES.)= 2.0 PEAKING FACTOR (INDUSTRIAL): 2.4 PEAKING FACTOR (ICI >20%): 1.5 PERSONS / SINGLE 3.35 PERSONS / TOWNHOME 3.35 PERSONS / MULTI-UNIT 2.25					COMMERCIAL 60,000 l/ha/day INDUSTRIAL (HEAVY) 55,000 l/ha/day INDUSTRIAL (LIGHT) 35,000 l/ha/day INSTITUTIONAL 60,000 l/ha/day INFILTRATION 0.28 l/s/Ha					MAXIMUM VELOCITY 4.50 m/s MANNINGS n 0.013 BEDDING CLASS B MINIMUM COVER 1.60 m HARMON CORRECTION FACTOR 1.00														
LOCATION			RESIDENTIAL AREA AND POPULATION										COMMERCIAL		INDUSTRIAL (L)		INDUSTRIAL (H)		INSTITUTIONAL		GREEN / UNUSED		C+H	INFILTRATION			TOTAL	PIPE									
AREA ID NUMBER	FROM M.H.	TO M.H.	AREA (ha)	SINGLE	UNITS TOWN	MULTI	POP.	CUMULATIVE AREA POP. (ha)	PEAK FACT.	PEAK FLOW (l/s)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	PEAK FLOW (l/s)	TOTAL AREA (ha)	ACCU. AREA (ha)	INFILT. FLOW (l/s)	FLOW (l/s)	LENGTH (m)	DIA (mm)	MATERIAL	CLASS	SLOPE (%)	CAP. (FULL) (l/s)	CAP. V PEAK FLOW (%)	VEL. (FULL) (m/s)	VEL. (ACT.) (m/s)			
R40A	40	39	34.59	0	0	0	196	34.59	196	4.00	3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	34.59	34.59	9.7	13.1	355.0	200	PVC	SDR 35	2.00	47.3	27.68%	1.49	1.06		
	39	38	0.00	0	0	0	0	34.59	196	4.00	3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	34.59	9.7	13.1	119.5	200	PVC	SDR 35	0.50	23.6	55.35%	0.74	0.65		
	38	37	0.00	0	0	0	0	34.59	196	4.00	3.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	34.59	9.7	13.1	101.3	200	PVC	SDR 35	0.50	23.6	55.35%	0.74	0.65		
	37	36	11.83	0	0	0	67	46.41	263	4.00	4.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	11.83	46.41	13.0	17.6	129.1	250	PVC	SDR 35	0.50	42.9	40.96%	0.86	0.69		
	36	35	0.00	0	0	0	0	46.41	263	4.00	4.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	46.41	13.0	17.6	137.8	250	PVC	SDR 35	0.50	42.9	40.96%	0.86	0.69		
	35	34	0.00	0	0	0	0	46.41	263	4.00	4.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	46.41	13.0	17.6	148.3	250	PVC	SDR 35	0.50	42.9	40.96%	0.86	0.69		
	34	33	0.00	0	0	0	0	46.41	263	4.00	4.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	46.41	13.0	17.6	114.5	250	PVC	SDR 35	0.50	42.9	40.96%	0.86	0.69		
	33	32	19.46	0	0	0	83	65.87	346	4.00	6.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	19.46	65.87	18.4	24.5	107.8	250	PVC	SDR 35	0.80	54.2	45.09%	1.09	0.91		
	32	31	40.43	0	0	0	173	106.30	519	3.97	8.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	40.43	106.30	29.8	38.7	226.2	250	PVC	SDR 35	1.50	74.3	52.11%	1.50	1.29		
R33B R32A	31	30	0.00	0	0	0	0	106.30	519	3.97	8.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	106.30	29.8	38.7	238.1	250	PVC	SDR 35	1.50	74.3	52.11%	1.50	1.29		
	30	29	0.00	0	0	0	0	106.30	519	3.97	8.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	106.30	29.8	38.7	885.7	250	PVC	SDR 35	1.40	71.7	53.94%	1.44	1.26		
R9A, G9A, G9B	9	8	9.29	0	0	0	76	9.29	76	4.00	1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	39.85	39.85	11.2	12.5	279.3	200	PVC	SDR 35	0.40	21.1	59.01%	0.67	0.60			
	8	7	0.00	0	0	0	0	9.29	76	4.00	1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	39.85	11.2	12.5	149.6	200	PVC	SDR 35	0.50	23.6	52.78%	0.74	0.65			
	7	6	0.00	0	0	0	0	9.29	76	4.00	1.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	39.85	11.2	12.5	186.0	200	PVC	SDR 35	3.00	57.9	21.55%	1.82	1.20			
	6	5	5.96	0	0	0	47	15.25	123	4.00	2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	5.96	45.82	12.8	15.0	92.4	200	PVC	SDR 35	4.61	71.8	20.85%	2.26	1.49			
	5	4	0.00	0	0	0	0	15.25	123	4.00	2.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	45.82	12.8	15.0	199.8	200	PVC	SDR 35	1.30	38.1	39.23%	1.20	0.96			
R20A, I20A, G20A, G20C, G20B, C20A	20	19	14.57	0	0	0	119	14.57	119	4.00	2.1	6.02	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.41	17.41	17.3	48.60	48.60	13.6	33.0	106.0	300	PVC	SDR 35	0.49	67.5	48.87%	0.96	0.81		
	19	18	0.00	0	0	0	0	14.57	119	4.00	2.1	0.00	6.02	0.00	0.00	0.00	0.00	0.00	10.60	0.00	17.41	17.3	0.00	48.60	13.6	33.0	167.2	300	PVC	SDR 35	0.50	67.9	48.58%	0.96	0.82		
	18	17	0.00	0	0	0	0	14.57	119	4.00	2.1	0.00	6.02	0.00	0.00	0.00	0.00	0.00	10.60	0.00	17.41	17.3	0.00	48.60	13.6	33.0	151.8	300	PVC	SDR 35	0.50	67.9	48.58%	0.96	0.82		
	17	16	2.31	0	0	0	15	16.88	134	4.00	2.3	0.00	6.02	0.00	0.00	0.00	0.00	0.00	10.60	0.00	17.41	17.3	2.31	50.91	14.3	33.9	204.0	300	PVC	SDR 35	1.40	113.6	29.83%	1.61	1.18		
	16	15	4.18	0	0	0	27	21.06	161	4.00	2.8	0.00	6.02	0.00	0.00	0.00	0.00	0.00	10.60	0.00	17.41	17.3	4.18	55.10	15.4	35.5	404.2	300	PVC	SDR 35	2.85	162.2	21.91%	2.30	1.54		
	15	14	0.00	0	0	0	0	21.06	161	4.00	2.8	0.00	6.02	0.00	0.00	0.00	0.00	0.00	10.60	0.00	17.41	17.3	0.00	55.10	15.4	35.5	127.1	300	PVC	SDR 35	3.00	166.3	21.37%	2.36	1.56		
	14	13	0.00	0	0	0	0	21.06	161	4.00	2.8	0.00	6.02	0.00	0.00	0.00	0.00	0.00	10.60	0.00	17.41	17.3	0.00	55.10	15.4	35.5	126.3	300	PVC	SDR 35	1.80	128.8	27.58%	1.83	1.30		
	13	4	0.00	0	0	0	0	21.06	161	4.00	2.8	0.00	6.02	0.00	0.00	0.00	0.00	0.00	10.60	0.00	17.41	17.3	0.00	55.10	15.4	35.5	343.2	300	PVC	SDR 35	0.80	85.9	41.38%	1.22	0.98		
R12A G11A, R11A	12	11	23.08	0	0	0	130	23.08	130	4.00	2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	23.08	23.08	6.5	8.7	331.6	200	PVC	SDR 35	0.40	21.1	41.23%	0.67	0.54			
	11	10	46.98	0	0	0	382	70.06	512	3.97	8.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	48.53	71.61	20.1	28.9	641.0	250	PVC	SDR 35	1.10	63.6	45.40%	1.28	1.06			
	10	4	0.00	0	0	0	0	70.06	512	3.97	8.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	71.61	20.1	28.9	196.7	250	PVC	SDR 35	3.96	120.7	23.93%	2.43	1.65			
G4A	4	3A	0.00	0	0	0	0	106.37	796	3.86	13.3	0.00	6.02	0.00	0.00	0.00	0.00	10.60	19.06	68.59	11.5	19.06	191.59	53.6	78.5	64.1	300	PVC	SDR 35	2.90	163.5	48.03%	2.32	1.97			
R26A, C26A	26	25	25.31	0	0	0	164	25.31	164	4.00	2.8	7.46	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.8	32.77	32.77	9.2	19.8	229.7	200	PVC	SDR 35	1.50	40.9	48.36%	1.29	1.09		
	25	24	0.00	0	0	0	0	25.31	164	4.00	2.8	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.8	0.00	32.77	9.2	19.8	117.7	250	PVC	SDR 35	0.40	38.3	51.62%	0.77	0.67		
	24	23	35.62	0	0	0	222	60.93	386	4.00	6.7	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.2	35.62	68.39	19.2	31.0	119.2	250	PVC	SDR 35	1.00	60.6	51.18%	1.22	1.05			
	23	22	0.00	0	0	0	0	60.93	386	4.00	6.7	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.2	0.00	68.39	19.2	31.0	217.4	250	PVC	SDR 35	1.00	60.6	51.18%	1.22	1.05			
	22	21	0.00	0	0	0	0	60.93	386	4.00	6.7	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.2	0.00	68.39	19.2	31.0	286.4	250	PVC	SDR 35	2.32	92.4	33.60%	1.86	1.41			
	21	3A	0.00	0	0	0	0	60.93	386	4.00	6.7	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.2	0.00	68.39	19.2	31.0	309.3	250	PVC	SDR 35	1.50	74.2	41.80%	1.49	1.22			



(Halifax)

FILE NUMBER: 160410459

MAX PEAK FACTOR (RES.)=	4.0	AVG. DAILY FLOW / PERSON	375	l/p/day	MINIMUM VELOCITY	0.60	m/s
MIN PEAK FACTOR (RES.)=	2.0	COMMERCIAL	60,000	ltha/day	MAXIMUM VELOCITY	4.50	m/s
PEAKING FACTOR (INDUSTRIAL):	2.4	INDUSTRIAL (HEAVY)	55,000	ltha/day	MANNINGS n	0.013	
PEAKING FACTOR (ICI >20%):	1.5	INDUSTRIAL (LIGHT)	35,000	ltha/day	BEDDING CLASS	B	
PERSONS / SINGLE	3.35	INSTITUTIONAL	60,000	ltha/day	MINIMUM COVER	1.60	m
PERSONS / TOWNHOME	3.35	INFILTRATION	0.28	l/s/Ha	HARMON CORRECTION FACTOR	1.00	
PERSONS / MULTI-UNIT	2.25						

LOCATION			RESIDENTIAL AREA AND POPULATION								COMMERCIAL		INDUSTRIAL (L)		INDUSTRIAL (H)		INSTITUTIONAL		GREEN / UNUSED		C+H	INFILTRATION			TOTAL	PIPE											
AREA ID NUMBER	FROM M.H.	TO M.H.	AREA (ha)	SINGLE	TOWN	MULTI	POP.	CUMULATIVE AREA (ha)	POP.	PEAK FACT.	PEAK FLOW (l/s)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	AREA (ha)	ACCU. AREA (ha)	PEAK FLOW (l/s)	TOTAL AREA (ha)	ACCU. AREA (ha)	INFILT. FLOW (l/s)	FLOW (l/s)	LENGTH (m)	DIA (mm)	MATERIAL	CLASS	SLOPE (%)	CAP. (FULL) (l/s)	CAP. V PEAK FLOW (%)	VEL. (FULL) (m/s)	VEL. (ACT.) (m/s)		
R40A	40	39	34.59	0	0	0	1882	34.59	1882	3.61	29.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	34.59	34.59	9.7	39.1	355.0	250	PVC	SDR 35	2.00	85.7	45.65%	1.73	1.43		
	39	38	0.00	0	0	0	0	34.59	1882	3.61	29.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	34.59	9.7	39.1	119.5	300	PVC	SDR 35	0.50	67.9	57.65%	0.96	0.86		
	38	37	0.00	0	0	0	0	34.59	1882	3.61	29.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	34.59	9.7	39.1	101.3	300	PVC	SDR 35	0.50	67.9	57.65%	0.96	0.86		
R37A	37	36	11.83	0	0	0	643	46.41	2525	3.50	38.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	11.83	46.41	13.0	51.4	129.1	300	PVC	SDR 35	0.50	67.9	75.72%	0.96	0.93		
	36	35	0.00	0	0	0	0	46.41	2525	3.50	38.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	46.41	13.0	51.4	137.8	300	PVC	SDR 35	0.50	67.9	75.72%	0.96	0.93		
	35	34	0.00	0	0	0	0	46.41	2525	3.50	38.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	46.41	13.0	51.4	148.3	300	PVC	SDR 35	0.50	67.9	75.72%	0.96	0.93		
R33B R32A	34	33	0.00	0	0	0	0	46.41	2525	3.50	38.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	46.41	13.0	51.4	114.5	300	PVC	SDR 35	0.50	67.9	75.72%	0.96	0.93		
	33	32	19.46	0	0	0	797	65.87	3322	3.40	49.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	19.46	65.87	18.4	67.5	107.8	375	PVC	SDR 35	0.80	145.2	46.52%	1.38	1.15		
	32	31	40.43	0	0	0	1666	106.30	4988	3.25	70.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	40.43	106.30	29.8	100.0	226.2	375	PVC	SDR 35	1.50	198.8	50.32%	1.89	1.61		
R9A, G9A, G9B	31	30	0.00	0	0	0	0	106.30	4988	3.25	70.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	106.30	29.8	100.0	238.1	375	PVC	SDR 35	1.50	198.8	50.32%	1.89	1.61		
	30	29	0.00	0	0	0	0	106.30	4988	3.25	70.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	106.30	29.8	100.0	885.7	375	PVC	SDR 35	1.40	192.0	52.09%	1.82	1.57		
	9	8	9.29	0	0	0	727	9.29	727	3.89	12.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	39.85	39.85	11.2	23.4	279.3	250	PVC	SDR 35	0.40	38.3	61.07%	0.77	0.70		
R6A	8	7	0.00	0	0	0	0	9.29	727	3.89	12.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	39.85	11.2	23.4	149.6	250	PVC	SDR 35	0.50	42.9	54.62%	0.86	0.76		
	7	6	0.00	0	0	0	0	9.29	727	3.89	12.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	39.85	11.2	23.4	186.0	250	PVC	SDR 35	3.00	105.0	22.30%	2.11	1.42		
	6	5	5.96	0	0	0	371	15.25	1098	3.77	18.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	5.96	45.82	12.8	30.8	92.4	250	PVC	SDR 35	4.61	130.1	23.68%	2.62	1.78		
R20A, I20A, G20A, G20C, G20B, C20A	5	4	0.00	0	0	0	0	15.25	1098	3.77	18.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	45.82	12.8	30.8	199.8	250	PVC	SDR 35	1.30	69.2	44.54%	1.39	1.14		
	20	19	14.57	0	0	0	1141	14.57	1141	3.76	18.6	6.02	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.41	17.41	17.3	48.60	48.60	13.6	49.6	106.0	300	PVC	SDR 35	0.49	67.5	73.41%	0.96	0.92		
	19	18	0.00	0	0	0	0	14.57	1141	3.76	18.6	6.02	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.41	17.41	17.3	0.00	48.60	13.6	49.6	167.2	300	PVC	SDR 35	0.50	67.9	72.98%	0.96	0.92		
R17A R16A	18	17	0.00	0	0	0	0	14.57	1141	3.76	18.6	6.02	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.41	17.41	17.3	0.00	48.60	13.6	49.6	151.8	300	PVC	SDR 35	0.50	67.9	72.98%	0.96	0.92		
	17	16	2.31	0	0	0	144	16.88	1285	3.73	20.8	0.00	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.41	17.3	2.31	50.91	14.3	52.4	204.0	300	PVC	SDR 35	1.40	113.6	46.08%	1.61	1.34			
	16	15	4.18	0	0	0	260	21.06	1545	3.67	24.6	0.00	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.41	17.3	4.18	55.10	15.4	57.3	404.2	300	PVC	SDR 35	2.85	162.2	35.36%	2.30	1.77			
R12A G11A, R11A	15	14	0.00	0	0	0	0	21.06	1545	3.67	24.6	0.00	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.41	17.3	0.00	55.10	15.4	57.3	127.1	300	PVC	SDR 35	3.00	166.3	34.49%	2.36	1.79			
	14	13	0.00	0	0	0	0	21.06	1545	3.67	24.6	0.00	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.41	17.3	0.00	55.10	15.4	57.3	126.3	300	PVC	SDR 35	1.80	128.8	44.52%	1.83	1.50			
	13	4	0.00	0	0	0	0	21.06	1545	3.67	24.6	0.00	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.41	17.3	0.00	55.10	15.4	57.3	343.2	300	PVC	SDR 35	0.80	85.9	66.78%	1.22	1.14			
G4A	12	11	23.08	0	0	0	1256	23.08	1256	3.73	20.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	23.08	23.08	6.5	26.8	331.6	250	PVC	SDR 35	0.40	38.3	69.93%	0.77	0.73		
	11	10	46.98	0	0	0	3677	70.06	4933	3.25	69.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	48.53	71.61	20.1	89.6	641.0	375	PVC	SDR 35	1.10	170.2	52.66%	1.61	1.41		
	10	4	0.00	0	0	0	0	70.06	4933	3.25	69.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	71.61	20.1	89.6	196.7	375	PVC	SDR 35	3.96	323.0	27.75%	3.06	2.18		
R26A, C26A	4	3A	0.00	0	0	0	0	106.37	7576	3.07	101.1	0.00	6.02	0.00	0.00	0.00	0.00	10.60	10.60	17.41	17.3	19.06	68.59	11.5	19.06	191.59	53.6	166.2	64.1	375	PVC	SDR 35	2.90	276.4	60.14%	2.62	2.36
	26	25	25.31	0	0	0	1577	25.31	1577	3.66	25.1	7.46	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.8	32.77	32.77	9.2	42.0	229.7	250	PVC	SDR 35	1.50	74.2	56.61%	1.49	1.32		
	25	24	0.00	0	0	0	0	25.31	1577	3.66	25.1	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.8	0.00	32.77	9.2	42.0	117.7	300	PVC	SDR 35	0.40	60.7	69.21%	0.86	0.81		
R24A	24	23	35.62	0	0	0	2219	60.93	3796	3.35	55.3	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.2	35.62	68.39	19.2	79.6	119.2	375	PVC	SDR 35	1.00	162.3	49.03%	1.54	1.30		
	23	22	0.00	0	0	0	0	60.93	3796	3.35	55.3	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.2	0.00	68.39	19.2	79.6	217.4	375	PVC	SDR 35	1.00	162.3	49.03%	1.54	1.30		
	22	21	0.00	0	0	0	0	60.93	3796	3.35	55.3	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.2	0.00	68.39	19.2	79.6	286.4	375	PVC	SDR 35	2.32	247.2	32.19%	2.34	1.76		
G2B, G2A	21	3A	0.00	0	0	0	0	60.93	3796	3.35	55.3	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.2	0.00	68.39	19.2	79.6	309.3	375	PVC	SDR 35	1.50	198.7	40.05%	1.88	1.50		
	3A	3	0.00	0	0	0	0	167.31	11372	2.90	143.1	0.00	13.48	0.00	0.00	0.00	0.00	10.60	10.60	16.7	16.7	0.00	259.98	72.8	232.6	156.8	450	PVC	SDR 35	1.80	403.3	57.68%	2.46	2.20			
	3	2	0.00	0	0	0	0	167.31	11372	2.90	143.1	0.00	13.48	0.00	0.00	0.00	0.00	10.60	10.60	16.7	16.7	0.00	259.98	72.8	232.6	104.3	450	PVC	SDR 35	1.80	403.3	57.68%	2.46	2.20			
R28A	2	1	0.00	0	0	0	249	167.31	11621	2.89	145.7	0.00	13.48	0.00	0.00	0.00	0.00	10.60	10.60	16.7	16.7	29.06	97.65	80.9	243.4	121.2	450	PVC	SDR 35	1.80	403.3	60.35%	2.46	2.23			
	28	27	31.47	0	0	0	1300	31.47	1300	3.72	21.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	31.47	31.47	8.8	29.8	569.2	200	PVC	SDR 35	3.75	64.8	46.06%	2.04	1.69		

Appendix C Drawings

